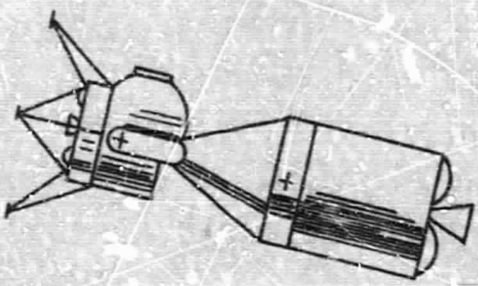
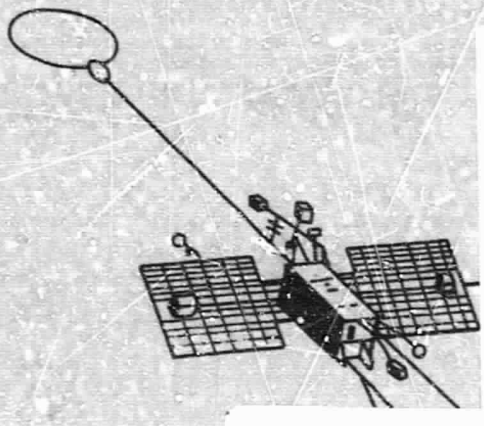
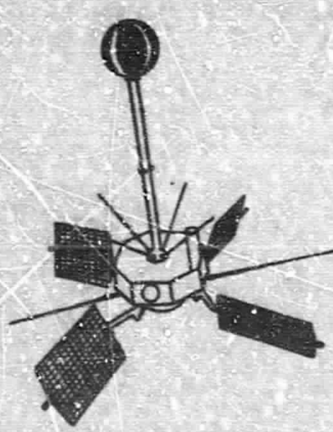
NHB 8030.1

# OPPORTUNITIES FOR PARTICIPATION IN SPACE FLIGHT INVESTIGATIONS











JULY 1965

OFFICE OF SPACE SCIENCE AND APPLICATIONS
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546

## PREFACE

In conducting the Nation's program of scientific investigations in space, the National Aeronautics and Space Administration seeks the participation of the most competent scientists and tries to conduct the investigations which will contribute the most to the advancement of our scientific knowledge. This is the fourth in a series of announcements designed to inform the scientific community of the opportunities for manned and unmanned flight missions. The opportunities listed in this document are necessarily tentative and are subject to change for scientific, technological or fiscal reasons. Copies of this announcement are sent to an extensive list of potential investigators in universities, industry, NASA field centers, and other government agencies. The announcement is also distributed to scientists in other countries both directly and through their national space organizations.

Interested scientists may propose:

1. Investigations to be conducted on one of the flight missions planned for the near future which are described in this announcement.

2. Investigations which would require missions not specifically planned.

3. Design studies for future scientific investigations.

Proposals for scientific investigations will be first evaluated for their scientific merit and technological feasibility. Proposals will be considered for the specific missions for which they were submitted. Investigators are advised to submit separate or updated proposals for each mission for which they wish to be considered. Proposals which would require new missions will be considered in the planning of new missions and in the selection of investigations for appropriate missions. Proposals for design studies will be evaluated in terms of their potential contribution to the scientific program.

The introductory section, following the Table of Contents, contains information and instructions which should be carefully reviewed by anyone intending to submit a proposal.

Homer E. Newell

Homer E. Newell
Associate Administrator for
Space Science and Applications

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## INTRODUCTION

### Basis For Selection Of Flight Experiments

For guidance and background information in connection with the preparation of proposals, the following sections are quoted from NASA Management Instruction No. 7100.1 on "Conduct of Space Science Program."

"Proposed flight investigations will be reviewed and evaluated from the scientific viewpoint on the following basis:

1. The scientific merit of the investigation, including both the desirability of the investigation within the discipline to which it pertains and the probability of acquiring positive scientific results. (Any investigation must require the use of space techniques to be considered for space flight).

2. The competence and experience of the investigator as an indication of his ability to carry his investigation to a successful conclusion.

3. The reputation and interest of the investigator's institution, especially from the point of view of whether the institution will provide necessary support to ensure that the investigation can be completed satisfactorily.

4. The scientific adequacy of whatever apparatus is proposed, particularly whether it can supply the data needed."

Generally, proposals for scientific experiments will be first and foremost evaluated for their scientific merit and technological feasibility. It is well recognized that experiments in space involve complex technological support. In the assignment of the various experiments to be carried out on an individual mission, these experiments are usually grouped so that correlated measurements may be made on a single flight. In the same context, the Explorer Project sometimes optimizes such a grouping by allowing several experiments to be carried out by a single institution.

In selecting investigations to be conducted on a specific mission the following procedure (again quoted from NMI 7100.1) is used:

"All proposed investigations will be grouped in terms of their value to the NASA Space Science Program in one of the categories indicated below:

Category I: Well-conceived and scientifically-sound investigations pertinent to the goals of the scientific program and the objectives of the particular mission, and offered by a competent investigator from an institution capable of supplying the necessary support to ensure

that satisfactory flight hardware can be delivered on time and that the data can be properly reduced, analyzed, interpreted, and published in a reasonable time after a successful launch.

Category II: Well-conceived and scientifically-sound investigations which are recommended for flight, but at a lower priority than Category I.

Category III: Scientifically-sound investigations which require further development of the associated experimental apparatus.

Category IV: Proposed investigations which are rejected for the particular mission under consideration."

Scientific investigations involving experimental research in space often may be satisfactorily undertaken by mounting instruments on one of several flight missions. A good proposal submitted for a given mission may be assigned to a flight mission other than that proposed: (1) because of scientific or technological reasons, (2) because space is not available on the mission for which the investigation was proposed, or (3) because the proposal was received at a time when a satisfactory flight mission was not available. In a number of cases, a flight mission using non-orbiting vehicles such as balloons or rockets may be prescribed.

## Responsibilities of the Principal Investigator

The following information is quoted from NASA Management Instruction No. 7100.1 concerning the responsibilities of the Principal Investigator:

### Role of the Principal Investigator

1. In addition to normal contractual responsibilities, the Principal Investigator is responsible for:

    a. Defining the investigation and the functional requirements for the instrumentation to be employed.

    b. Ensuring that an adequate research program is conducted to minimize the possibility of ambiguous interpretation of the data.

    c. Organizing the efforts of, assigning tasks to, and guiding other members of his team of investigators.

    d. Timely processing, analysis and publication of investigation results and findings.

2. Upon his selection to participate in a flight, a Principal Investigator becomes a member of the project team and is normally responsible to the Project Manager for:

   a. Developing and constructing the instrumentation for the investigation on a basis compatible with approved schedules and consistent with optimum project cost effectiveness.

   b. Ensuring that the design and construction of the instrumentation, its development and test program are appropriate to the objectives of the investigation, and reflect properly the environmental and interface constraints under which the instrumentation must operate.

   c. Ensuring that adequate calibrations are made through the entire data acquisition and transmission system if necessary.

   d. Ensuring that plans are made and implemented to process, analyze and report on the results of the investigation.

   e. Participating in the operational phase of the mission as may be required.

## Proposal Preparation

At least one copy of the proposal should be clear black on white, of a quality suitable for reproduction. Proposals should be written and submitted in two parts -- a technical section (30 copies) and a management section (15 copies). Each proposal intended for a specific mission should conspicuously identify the particular flight mission for which the experiment is proposed and the person listed in the "Technical Contact" column of the "Schedule of Flights and Proposal Deadlines." Proposals should be endorsed by an official authorized to commit the proposing organization. No rigid proposal format is prescribed for unmanned flight experiments, but proposals should be specific and cover points suggested here.

Proposals for experiments on manned spacecraft should cover the points suggested here and follow Form 1138, a, b, and c included in the rear of this book.

### Identifying Information

A descriptive short title of the experiment, the name of the organization, and the date of preparation or submission.

### Abstract or Summary

A simple, concise statement about the investigation, how it will be conducted, and expected results.

## Technical Section

Strive to keep the technical section less than ten pages. The time and concentration an evaluator can devote to a proposal is inversely proportional to its length. The technical section should include, as a minimum:

1. <u>Statement of Objectives and Major Requirements</u>.

(A description of the scientific goals to be attained by the investigation, specifying the orbit required and indicating the effect of deviations from the required orbit on the attainment of the experimental objectives. Unique constraints which the investigation may place on other instruments in the spacecraft and any unique requirements of the investigation itself.)

2. <u>Background Discussion</u>.

(Discussion of related information on which the investigation is based and which demonstrates the need for the investigation.)

3. <u>Techniques and Instruments to be Employed or Developed</u>.

(A detailed description of the investigation and the instrumentation associated therewith. Present state of development of the instrumentation for the investigation including previously obtained test or experimental data.)

4. <u>Physical Characteristics of Equipment and State of the Art</u>.

a. Weight, volume, and shape with tolerances.
(Note that booms, power converters, balancing booms, and/or weight may be chargeable to the investigator.)

b. Power profile in all operating, non-operating, and possible failure modes.

c. Telemetry requirements.

d. Desired data acquisition duty cycle.

e. Salient characteristics of the experiment necessary to judge its scientific merit such as : Geometric factor, dynamic range, the lower limit of sensitivity, time resolution and telemetry bit rate requirements (give acceptable limits), and anticipated background rates.

f. Expected susceptibility of the flight package to radio frequency and magnetic interference and, in turn, its tendency to produce RFI and magnetic interference.

5. Other Requirements for the Investigation.

a. List of essential or desirable supporting experiments.

b. Other special requirements such as:

(1) Data storage between periods of data readout.
(2) Preferred location on the vehicle.
(3) Preferred viewing direction.
(4) Spacecraft openings desired.
(5) Isolation needed.
(6) Temperature environment.
(7) Readout methods desired.
(8) Operation program.

6. Results Expected.

(While it may not be possible to anticipate in detail the nature of the results to be obtained, some general indication should be attempted.)

7. Data Reduction & Analysis.

Estimate of time required by the Principal Investigator to analyze and evaluate the data from his investigation. General estimate of time and effort to be expended, and whether manual or automatic methods will be used. Plan for reduction of data to scientific format and proposed format in which data will be returned to the National Space Science Data Center.

Management Section

1. Work Plan

a. Details of the management plan for the work, including proposed functions of the Principal Investigator and his identity.

b. The names and addresses of the Co-Investigators.

c. The names, titles, and experience resumes of key scientific, engineering, and business management personnel.

d. Performance schedule for the proposed tasks. Time when certain specific phases of the work are expected to be completed, including preliminary investigations.

2. Cost Proposal (U.S. Investigators only)

a. A Cost Proposal (indicating leadtimes) and patterned closely after the outline should be included as part of the management section

(1) Separate categories of Direct Labor, giving hours or man/months and rate per hour. There should be included (1) what the personnel involved will do and when it is to be done, (2) actual salaries of all people who would be working on the project, and (3) specific notation of the fraction of time to be devoted by part-time personnel.

(2) Overhead. (Rate in percent)

(3) Bill of Materials including estimated cost of each particular.

(4) Subcontracts. List those over $25,000 and specify the vendor and basis for estimated costs.

(5) A list of Special Equipment, its proposed use, and estimated cost.

(6) Travel. Number of trips, destinations, duration, purpose, number of people involved, and forecast date of travel.

(7) Data Reduction & Analysis. Give plans for type and amount of data reduction and analysis and estimated cost. The plan should provide for reduction of all acquired data to a format suitable for analysis by other investigators and for return of reduced data to the National Space Science Data Center.

(8) Other Items. Explain similar to the above.

(9) Give Total Direct Costs (sum of all the above). Add rate of General and Administrative Costs and give Total Estimated Cost.

b. A quarterly spending curve should also be included, to insure proper funding throughout the contract

Proposal Submission

Proposals from domestic sources in universities, industries, and government installations other than NASA field centers should be mailed to:

Director, Office of Grants & Research Contracts
Code SC
National Aeronautics & Space Administration
Washington, D. C. 20546

with a request that 25 copies of the technical section and 10 copies of the management section be forwarded to the appropriate technical contact.

Proposals from NASA field centers should be mailed to:

Office of Space Science and Applications
Attention: (Appropriate Technical Contact,
as given in the Schedule of Flights and
Proposal Deadlines)
National Aeronautics & Space Administration
Washington, D.C. 20546

Proposals from foreign sources should be submitted through your official national space or scientific organization to:

Office of International Affairs
Code AI
National Aeronautics & Space Administration
Washington, D.C. 20546

Preparation and Distribution of this Document

This document was assembled, edited, and coordinated by the Physics and Astronomy Programs, Headquarters, NASA. Communications concerning its contents and distribution should therefore be addressed to:

Physics and Astronomy Programs
Code SG
Office of Space Science and Applications
National Aeronautics & Space Administration
Washington, D.C. 20546

These general announcements of opportunities are being issued on a semi-annual basis. Each investigator should notify the Office of Space Science and Applications as soon as possible of his intention to seek participation in a particular flight mission so that he may be notified of any changes in scheduling or mission characteristics. These changes will not be issued as general announcements. Copies of these notifications sent from investigators ouside the U. S. should be directed to the Office of International Affairs.

## SCHEDULE OF FLIGHTS

| PROJECT | MISSION | PROPOSAL DEADLINE | DATE FLIGHT[1] PROTOTYPE REQUIRED | DATE FLIGHT[1] UNIT REQUIRED | YEAR OF FLIGHT |
|---|---|---|---|---|---|
| ISIS | B | 1 Jan 66 | --- | --- | 1968 |
| Unscheduled Explorers | --- | 1 Jul 66[2] | --- | --- | Open |
| OSO | G | 1 Jan 66 | Jul 1967 | Jan 1968 | 1968 |
| | A-B | 15 Sep 65 | Sept 1967 | Jul/Nov 68 | 1969-70 |
| | C | 1 Jun 66 | Sept 1968 | Nov 1969 | 1971 |
| AOSO | D | 1 Jun 67 | Sept 1969 | Nov 1970 | 1972 |
| | K-N | 8 Oct 65 | 1 Jan 67 | 1 May 67 | 1968 |
| Surveyor | O-Q | 12 Nov 65 | 1 Sept 67 | 1 Jan 68 | 1969 |
| Lunar Orbiter Selenodesy Program | A-E | 15 Sep 65 | --- | --- | 1966-67 |
| | | 15 Aug 65[3] | --- | --- | 1971 |
| Voyager | Mars 71 | 19 Nov 65[4] | --- | --- | --- |
| TIROS | --- | Open | --- | --- | --- |
| | B | May 65 | Apr 66 | Dec 66 | 1967 |
| Nimbus | D | Jul 66 | Jul 67 | Apr 68 | 1969 |
| Sounding Rockets and Balloons | --- | Proposal req'd 12 months before launch | --- | --- | Open |
| X-15 Research Airplane | --- | Proposal req'd 12 months before launch | --- | --- | Open |
| Convair 990 Research Airplane | --- | Open | --- | --- | Open |
| Apollo Earth-Orbital | All | Two years before launch | Est. 12 mos. before launch | Est. 6 mos before launch | 1966-69 |
| Extended Apollo Manned Earth-Orbital | --- | 1 Jan 66 | --- | --- | 1969 |
| Apollo Manned Lunar Landing | Third, or later | 1 Jan 66 | --- | --- | Before 1970 |
| Extended Apollo Manned Lunar Orbital | --- | 1 Jan 66 | --- | --- | 1969-72 |
| Extended Apollo Manned Lunar Surface | --- | 1 Jan 66 | --- | --- | 1970-72 |

[1]Entries contained in these columns are for planning purposes only. Specific hardware delivery dates will be arranged between the project management and the principal investigator.

[2]Administrative deadline to facilitate review. Proposals received after this date will be considered in a later review.

AND PROPOSAL DEADLINES

| FLIGHT CHARACTERISTICS APOGEE | PERIGEE | INCLIN. | LIFETIME | TECHNICAL CONTACT |
|---|---|---|---|---|
| 3500Km | 1000Km | 80° | 12 mos | Mr. R. Miller, Code SG |
| --- | --- | -- | --- | Mr. M.J. Aucremanne, Code SG |
| 550-55Km (circ) | | 33° or Polar | 6 mos | Mr. R.E. Halpern, Code SG |
| 612 Km(circular) | | Polar (retro) | 12 mos | Mr. D. L. Forsythe, Code SG |
| Lunar Soft Landing " " " | | | 17 earth days, max. | Mr. S. E. Dwornik, Code SL |
| 1850Km (apolune) | 46Km (perilune) | 14° (lunar) | 12 mos | Dr. M. J. Swetnick Code SL |
| --- --- | --- --- | -- -- | --- --- | Dr. R. F. Fellows, Code SL |
| --- | --- | -- | --- | Mr. M.L. Garbacz, Code SFF |
| 1110 to 1390 Km (circular) | | 80° (retro) | 6 to 12 mos | Dr. R. L. Haley, Code SFE |
| --- | --- | -- | --- | Mr. J. R. Holtz, Code SG |
| --- | --- | -- | --- | Mr. E. J. Ott, Code SG |
| --- | --- | -- | --- | Mr. M. Dubin, Code SG |
| --- | --- | -- | --- | Dr. J. R. Gill, Code SM |
| --- | --- | -- | --- | Dr. P. C. Badgley, Code SM |
| --- | --- | -- | --- | Mr. E. M. Davin, Code SM |
| --- | --- | -- | --- | Dr. P. C. Badgley, Code SM |
| --- | --- | -- | --- | Dr. R. J. Allenby, Code SM |

[3] In preliminary form.

[4] Complete and in final form.

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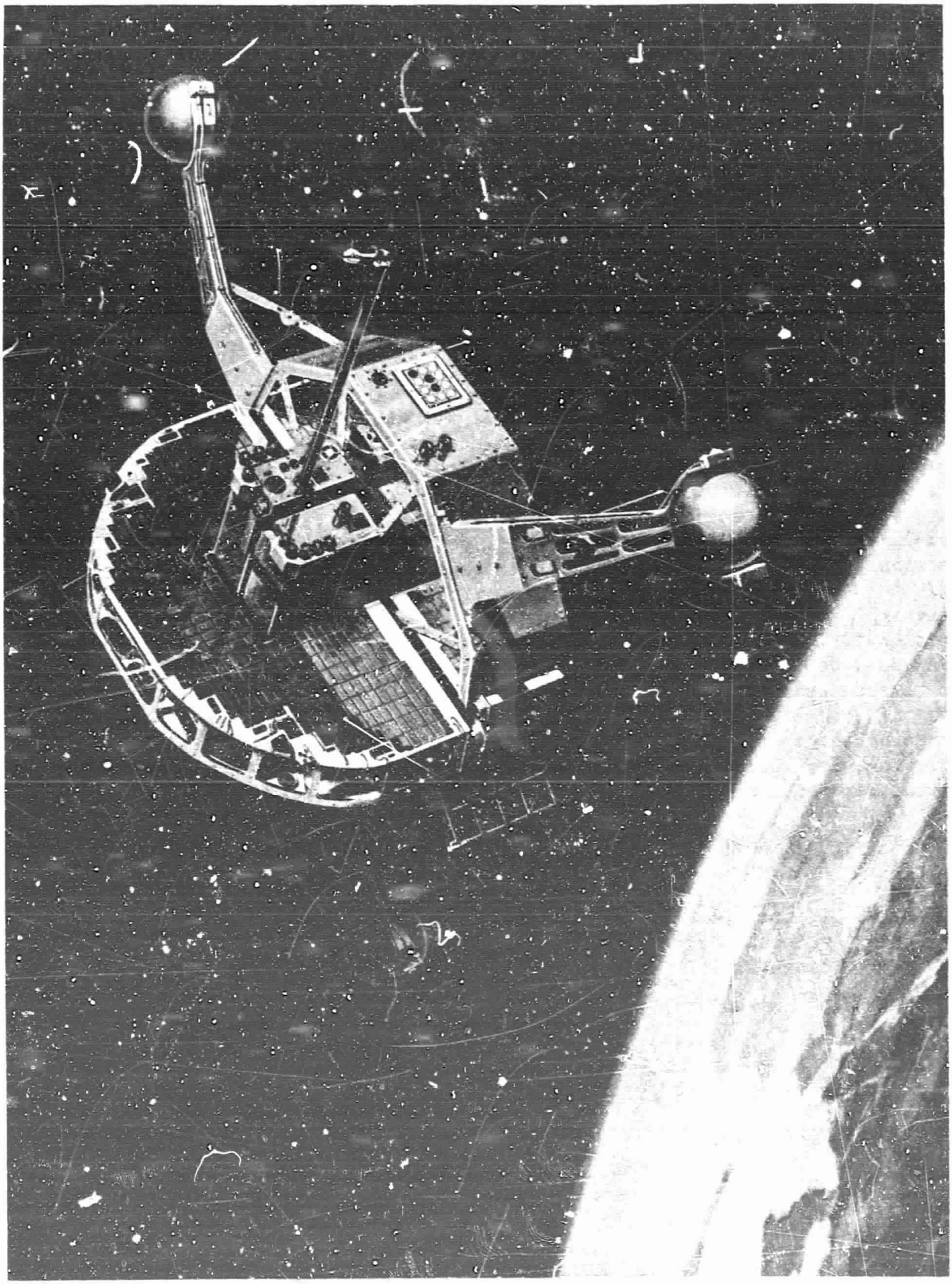
## Procedures for Proposing, Selecting and Flying Foreign Experiments on NASA Aircraft and Spacecraft

If a scientist from outside the United States desires to submit an experiment proposal for NASA's review, it should be sent first to the official national space research organization in the scientist's country (or a regional space research organization). This organization will then forward the proposal to NASA where it will go through the same evaluation and selection process as a U.S.-originated proposal.

Should the experiment be selected for flight, NASA would expect to arrange for its inclusion on a no-exchange-of-funds basis with the sponsoring national or regional space research organization. The arrangements for this are for NASA and the sponsoring organization to bear the cost of discharging their respective responsibilities, with the sponsoring organization normally being responsible for building, testing, and evaluating the experiment, for following it through to countdown, for transferring data tapes to the country in question, for further reducing the data, and for analyzing it. The organization would also provide travel and transportation expenses for the personnel and equipment for which it is responsible. NASA would be responsible for providing acceptance testing of the flight experiment, qualification testing of a prototype, integrating the equipment into the spacecraft, testing and evaluating the integrated spacecraft, launching the spacecraft, acquiring data, accomplishing preliminary data reduction, and bearing the cost for the travel and transportation charges for the personnel and equipment for which it is responsible.

Any inquiries concerning this procedure should be directed to:

Office of International Affairs, Code AI
National Aeronautics and Space Administration
Washington, D.C. 20546



ORBITING SOLAR OBSERVATORY

# ORBITING SOLAR OBSERVATORY

## Introduction

The Orbiting Solar Observatory (OSO) Program will conduct experiments in solar physics, astronomy and geophysics from a stabilized platform above the earth's atmosphere. Preference in selection of experiments will be given to investigations which detect and measure electromagnetic radiations from the sun. The OSO Program consists of eight planned launches. On March 7, 1962 OSO-I was successfully launched from Cape Canaveral into a 300 nautical mile circular orbit. Over 2,000 hours of data on solar phenomena have been collected from this satellite. On February 3, 1965 OSO-II was successfully launched from Cape Kennedy and continues to transmit data as of this date.

Payloads for OSO-C, -D, -E and -F have been selected. Proposals for OSO-G and -H, to be flown in 1968 and 1969, respectively, are currently being considered.

In the current series, OSO will be placed into a circular orbit of 300 ±30 nautical miles (550 ±55 km) altitude and about 33 degrees inclination with a period of about 95 minutes. A study is underway to ascertain the feasibility of placing later OSO missions into a retrograde polar orbit of 300 ±30 nautical miles (550 ±55 km) in order to take advantage of full sunlight. Therefore, experiment proposals utilizing a polar orbit will be considered for OSO-G and -H. Design life of OSO is nominally six months.

Nominal lead time for delivery of prototype experiments for integration is one year prior to launch date. Flight experiments are expected to follow approximately six months later. Specific dates for delivery will be discussed at the time of selection of experiments for a given mission.

## Spacecraft Description

The Orbiting Solar Observatory (OSO) is a standardized 500 pound (226 kg) spacecraft designed primarily as a stabilized platform for solar oriented scientific instruments. The spacecraft has two main sections. The lower wheel-like structure is composed of nine wedge-shaped compartments. Five of these compartments are available for scientific instruments; the other four are used to house some of the electronic controls, batteries, and all the telemetry system, radio command system, and in-flight data storage system. Three spheres on extended arms store nitrogen for the spin control system. Two of these arms also act as radiating antennae. The wheel section rotates to provide gyroscopic stability.

The semi-circular sail section mounted above the wheel carries instrument packages which are pointed toward the center of the solar disc with nominal accuracy of $\pm 60$ seconds of arc. The wheel section spin rate is maintained at 30 $\pm 1\frac{1}{2}$ rpm by gas jets on the three arms.

Payload Environment

Space is available in the sail section of the satellite for instruments which must point directly at the sun. The accuracy of this pointing is nominally $\pm 60$ seconds of arc; however, OSO-II is currently achieving an accuracy of better than 30 seconds of arc. The pointing compartment is 8" x 8" x 36" (20 x 20 x 91 cm) and can carry approximately 100 pounds (45 kg) of equipment. On the OSO missions for which experiments have thus far been selected, this compartment has been split into two packages, each 4" x 8" x 36" (10 x 20 x 91 cm). A scan capability with a resolution of 1 arc minute can be made available for these pointed experiments. The scan is a square raster pattern 40 minutes of arc on a side, centered on the maximum intensity of the solar disc.

Five wedge-shaped sections are available in the wheel for the instruments. Each wedge section has a volume of approximately 1,000 cubic inches (6,450 $cm^3$) and can carry up to 30 pounds (13.6 kg) of equipment. Each section rotates across a sun vector every two seconds. It is feasible to remove the structural member separating two adjoining wedge sections, thus doubling the availability of space for a given instrument.

Thermal control of OSO is accomplished passively by the use of surfaces on the spacecraft with well controlled optical properties. The rim panels of the spacecraft receive passive solar energy throughout the observatory day as do the front of the pointed instruments and the solar cells mounted on the upper sail section. The outer surfaces of the spacecraft also receive heat energy from the sunlight reflected from the earth and from internal heat sources. During observatory night, the entire spacecraft receives no solar heat but is maintained at a relatively warm operating temperature by the low emissivity of the outer surfaces. Instruments within the wheel compartment should be capable of operating between 0°C to +20°C. The deviation from the equilibrium temperature reached can be expected to be $\pm 3°$ from night to day. Measured results from the OSO-I indicate that the internal temperature of a pointed instrument can be maintained in a region of 0° to $\pm 10$°C.

Throughout the launch and injection phases of the operation, the payload experiences severe static and dynamic accelerations. The static acceleration from the three stages of the boost reaches a maximum of 12g along longitudinal axis and 3g along the lateral axis. The dynamic acceleration or vibration introduced is a maximum during testing of 25g peak to peak in the region of 75-125 cycles per second directed along the longitudinal or spin axis of the spacecraft and, correspondingly, 10g peak to peak in a region of 20-80 cycles per second directed along

the lateral axis. In addition to the boost acceleration, the spin of the entire spacecraft introduces the centrifugal force to all instruments according to the radial mass distribution. Power is supplied to the spacecraft through the solar cell array mounted on the sail. During the satellite night, nickel-cadmium batteries are used to supply power when necessary. Approximately 11 watts of unregulated power are available for the entire experiment payload.

Launch Phase

The OSO spacecraft will be placed into orbit by a 3-stage Delta launch vehicle from the Eastern Test Range (ETR), Cape Kennedy, Florida. Following the launch of OSO-C in 1965, OSO's will be launched approximately every nine months.

If it is decided to place the OSO-G and -H into a retrograde polar orbit, launch will take place on an improved Delta from the Western Test Range (WTR), Vandenburg Air Force Base, California. Launch of OSO-G and -H will take place in 1968 and 1969, respectively.

Stabilization

The Orbiting Solar Observatories are stabilized in the pitch and yaw axis only. Motion about the roll axis of the spacecraft is uncontrolled but this motion has been determined to be less than 1 degree per day.

Pitch and yaw of the spacecraft are controlled separately; pitch control is an automatic feature capable of holding the spacecraft to within ±1 arc minute using an internally-held nitrogen gas supply. Control of the fine instruments in the yaw plane are controlled by servo motors which position the pointed instruments to within ±1 arc minute of the center of the solar disc. While there is no control around the roll axis of the spacecraft, instruments on board enable experimenters to determine the position of the satellite in roll at any given point in time. The axis of the instruments within the wheel section of the spacecraft pass within 3 minutes of the solar vector.

Power Supply

A solar cell array mounted on the sail section converts solar energy into electrical power whenever the spacecraft is in sunlight. This power is stored in nickel-cadmium batteries housed in the spinning wheel to provide a nearly constant voltage when the spacecraft is in darkness. Average power from the solar cell array is approximately 26 watts and approximately 11 watts of unregulated power are available for the entire experiment payload.

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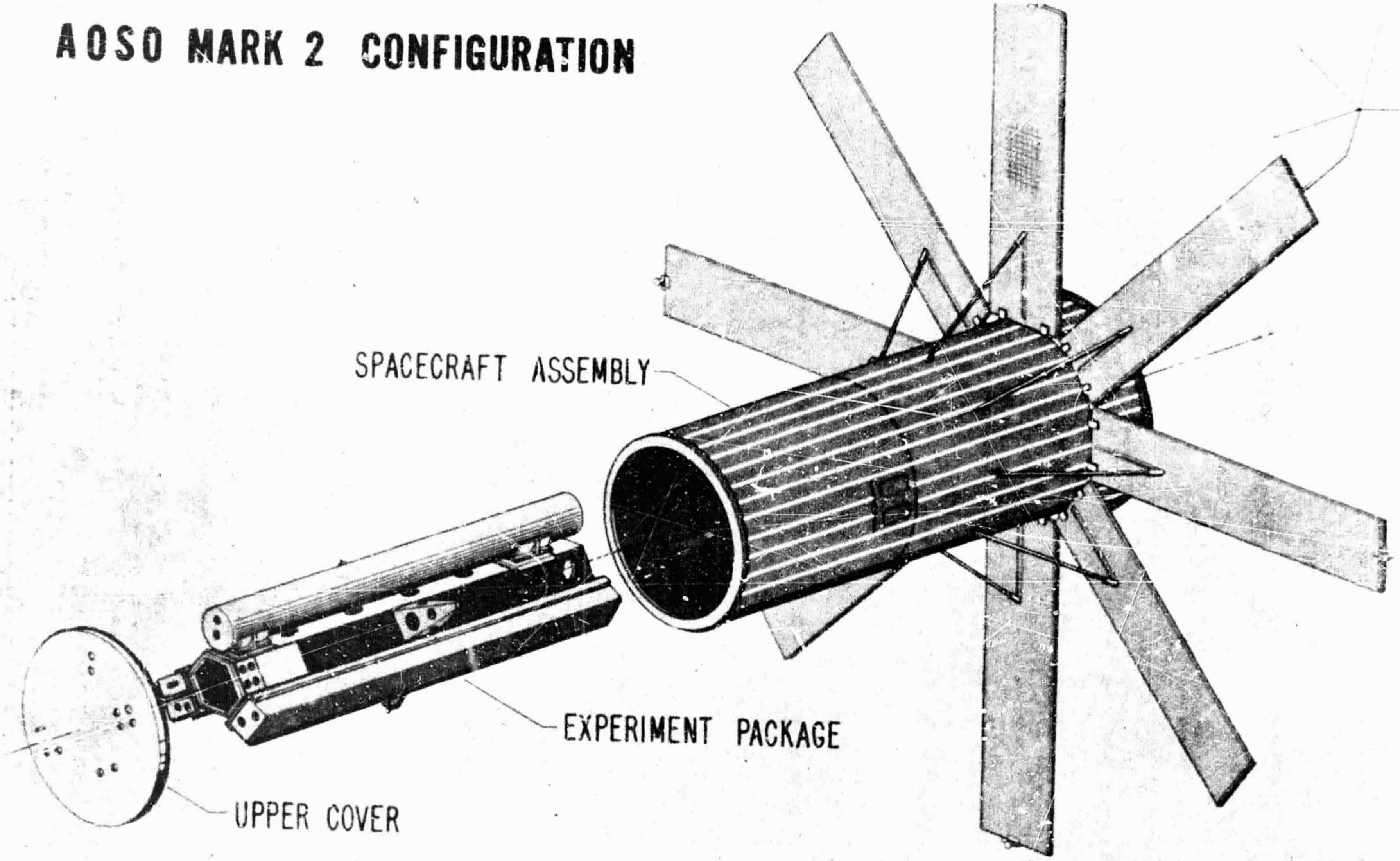
# AOSO MARK 2 CONFIGURATION




ADVANCED ORBITING SOLAR OBSERVATORY

# ADVANCED ORBITING SOLAR OBSERVATORY

## Introduction

The Advanced Orbiting Solar Observatory (AOSO) will make continuous, detailed, high-resolution studies of solar phenomena in order to understand the mechanisms which cause their occurrence. Instrumentation for viewing the solar spectrum in the gamma ray, X-ray, ultraviolet, visible and infrared regions will be developed as a part of this program.

Scientific instrumentation for the initial AOSO missions is currently under development. Proposals for instrumentation of an AOSO to be flown in 1969-70 are being considered. The tentative deadline for these proposals is 15 September 1965. Individuals planning to propose are encouraged to communicate with the AOSO Program Manager prior to submission. Planned orbit will be polar retrograde at an altitude of 330 nautical miles (612 km) with a period of about 95 minutes. A retrograde orbit will be employed to obtain the maximum possible length of time in full sunlight operation. Operational life goal is one year.

The following is a compilation of information particularly useful for potential experimenters on the Advanced Orbiting Solar Observatory (AOSO). In all cases the best current information is given since the spacecraft is still under development. As the information on this satellite increases, improvements will be made; when this happens experimenters will be notified as promptly as possible.

## Spacecraft Body

The AOSO spacecraft consists of a cylindrically shaped housing 120 inches (3.048m) long and a diameter of 55 inches (1.4m), housing the experiments and the spacecraft support equipment. A rigid, hollow hexagonal experiment support structure of aluminum honeycomb construction is provided for mounting the experiments. Eight solar paddles are attached to the end of the cylinder, and face the sun to provide power to the spacecraft. A total observatory weight of 1200 pounds (544.3kg) includes 250 pounds (113.4kg) of experiment instrumentation.

## Payload Environment

(1) Experiment Volume:

Annular cross section: OD=44 inches (1.12m), ID=15 inches (.38m), by about 100 inches (2.54m), along axis toward the sun. Spacecraft components, such as the fine sun sensor and the star tracker, must also be located within this volume.

(2) Weight:

250 pounds (113.4kg) maximum available for combined experiments, associated electronics, supporting structure and ballast.

(3) Vibration:

It is recommended that experiments be designed for a minimum equivalent static load factor of ±25g in the longitudinal direction, ±20g in the lateral direction associated with torsion of the support tube, and 10g in any other lateral direction.

(4) Shock:

Shock loadings tests to simulate launch environment will be as follows:

| Direction | Amplitude | Time Duration | Waveform |
|---|---|---|---|
| Longitudinal axis | ±17g | 11 MSEC | ½ sine |
| Lateral/ Transverse | ±6g | 11 MSEC | ½ sine |

(5) Temperature:

0° to 40°C approximately isothermal and constant.

(6) Power Available for Experiments:

Average power available to experimenters is 75 watts while in sunlight. Peak power of 100 watts is available twice per orbit for a period up to one minute each. Limited power will be available for the experiments during any period the observatory is occulted. The power supply voltage will be 28 + 8.0 volts/-4.5 volts DC. Any inversion, conversion or closer regulation of this power must be supplied by the individual experimenters.

Launch Phase

Launch will be from the Western Test Range (WTR), Vandenberg Air Force Base, California, by a Thrust Augmented Thor-Agena D vehicle. The first launch is planned for 1969 and one per year for the next three years.

Stabilization and Control

A three-axis stabilization and control subsystem provides the following three pointing modes for the experiments:

(1) Normal Orientation:

Normal orientation pointing accuracy to be within ±5 arc seconds of the center of the sun with a jitter of ±1 arc second maximum and a minimum jitter rate of 0.5 arc seconds per second of time.

(2) Offset Pointing:

Fine offset pointing with an accuracy of ±5 arc seconds (with jitter and jitter rate the same as for normal orientation) to any position within a 40 arc minute square centered on the sun.

(3) Raster Scanning:

In this mode the optical axis of the observatory is made to scan either of two patterns which are centered about an offset point.

(a) One pattern is a 40 arc minute square, scanned by 120 lines spaced 20 arc seconds apart (coarse scan). The nominal scan velocity is 200 arc seconds per second of time.

(b) The other pattern is a 5 arc minute square, scanned by 60 lines spaced 5 arc seconds apart (fine scan). The fine scan can be accomplished only within the 40 arc minute square centered on the sun. Scan patterns shall originate and terminate at an offset point. Two nominal scan velocities are available; one velocity of 100 arc seconds per second of time and the other of 50 arc seconds per second of time.

Power Supply

The power supply system provides for the generation, storage, regulation and conversion of the spacecraft equipment requirements. It has a capacity for the installation of 43,000 N on P silicon cells providing a total power of 680 watts. Two fully redundant 20 ampere-hour nickel-cadmium batteries are provided for launch load peaks and for orbital eclipse periods.

## Tracking

Prior to launch, GSFC will provide each experimenter with a world map of subsatellite points at one minute of time intervals. The world map is based upon calculations of the theoretically perfect orbit.

## Communication and Data Handling

The communication and data handling subsystem design conversion will consist of equipment that provides for the major functions of commands, data handling and telemetry. Summary of operating characteristics is as follows:

(1) Command:

| | |
|---|---|
| Primary Commands: | 254 (total of 100 for experiments) |
| Stored Commands: | 147 |
| Command Rate: | Up to 4/sec at intervals of 32 seconds or combinations thereof up to 1984 seconds |

(2) Data Handling:

(a) Narrow Band:

| | |
|---|---|
| Bit Rate: | 480 bits/sec |
| Encoding Accuracy: | 8 bits/word |
| Major Frame Period: | 32 seconds |
| One Major Frame: | 1920 words |

(b) Wide Band:

| | |
|---|---|
| Bit Rate: | 3840 bits/sec |
| Encoding Accuracy: | 8 bits |
| Frame Period: | 1 second |
| Data Storage: | $40 \times 10^6$ bits/tape recorder (approximately) |

(c) Combined:

| | |
|---|---|
| Bit Rate: | 4320 bits/sec |
| Word Length: | 9 bits |
| Major Frame Period: | 32 seconds |
| Major Frame Length: | 480x32 words |

(3) Telemetry:

(a) Command: PCM-NRZ(c) FSK/AM/AM
(b) Narrow Band and Wide Band (Real Time): PCM/PM(NRZ)
(c) Narrow Band and Wide Band (Recorder Playback): PCM/FM(NRZ)

Observatory operational control will be available at prime data acquisition stations and the Goddard Space Flight Center (GSFC).

Data processing and reduction will be done at GSFC by the Space Data Acquisition Division.

Materials

The GSFC will provide a list of suitable materials for specific applications and will provide technical assistance to the experimenters.

For further information contact Mr. Dixon L. Forsythe, AOSO Program Manager, Physics and Astronomy Programs, Office of Space Science and Applications, NASA Headquarters, Washington, D.C. 20546.

TABLE I - AOSO INSTRUMENTATION

UNDER DEVELOPMENT

1. Title: 300A to 1300A Normal Incidence Scanning Spectrometer-Spectroheliometer Suitable for an AOSO Spacecraft
   Submitted by: Harvard College Observatory
   Principal Investigator: L. Goldberg
   Co-Investigators: E. M. Reeves, W. H. Parkinson

2. Title: High Resolution (5 arc seconds) X-ray Telescope
   Submitted by: Goddard Space Flight Center and American Science & Engineering, Inc.
   Principal Investigator: J. C. Lindsay
   Co-Investigator: R. Giacconi

3. Title: Design and Construction of White Light Coronagraph for AOSO
   Submitted by: High Altitude Observatory
   Principal Investigator: G. Newkirk, Jr.
   Co-Investigator: J. A. Eddy

4. Title: Ultraviolet Spectroheliographs
   Submitted by: Naval Research Laboratory
   Principal Investigator: J. D. Purcell
   Co-Investigators: R. Tousey, H. Friedman

## SURVEYOR

## MISSIONS K THROUGH Q

### A. Introduction

The Surveyor spacecraft is being developed to accomplish soft landings on the Moon with instrumented payloads. On the lunar surface it will survey various areas of interest as possible sites for manned laundings and provide a wide variety of scientific data to improve our understanding of the nature of the Moon. Landed Surveyors will serve as remote observation posts and radio-controlled lunar laboratories; they will transmit to earth on-site data such as high-resolution television pictures of the lunar terrain and fine details of the surface texture, measurements of the surface hardness and other physical and chemical properties, lunar seismic activity, the micrometeorite environment near the surface, and other fundamental lunar data. Some Surveyors will serve as beacons or site location markers for Apollo operations.

Proposals will be considered for experiments and Apollo support equipment to be carried to the Moon on Surveyor Missions K-Q which are scheduled to begin in mid-1968. The payloads for Surveyor Missions A-J scheduled for the period of late 1965 through early 1968 have already been defined. Missions A-D are engineering flights to test the spacecraft system; they will carry a survey television camera in addition to engineering instrumentation. Operational Missions E-J will carry the experiments shown in Table 1.

Since a major objective of the Surveyor program is to provide information essential to early manned lunar missions, in the selection of experiments for Missions K-Q particular consideration will be given to proposed scientific experiments which will contribute new knowledge important to manned missions.

### B. Proposals for Experiments

Scientific investigators are invited to:

1. Propose scientific experiments which will make use of the data to be provided by basic furnished equipment, such as the spacecraft's elevated imaging system, the performance of the spacecraft in landing, etc. (See Section C for descriptions.)

2. Propose other scientific experiments (or Apollo support functions) to be conducted with specific instrumentation or equipment suggested by the proposer, such instrumentation or equipment to be compatible with the spacecraft constraints defined in Section D.

3. A passive location aid to serve as a landing site marker for Apollo is also being considered and proposals for such a device will be welcome.

Although primary consideration will be given to experiments to be conducted on the lunar surface, it may be possible to conduct selected experiments during the transit to the Moon and during the landing.

## C. Spacecraft Configuration

The basic Surveyor spacecraft is a three-legged structure with thermally controlled compartments and equipment mounted on the spaceframe (see Figure 1). The retro motor is housed on the axis of the structure and the various sensing devices and pressure vessels are fitted to the frame. At the broadest point the spacecraft is approximately 105 inches (2.67 m.) in diameter. The spacecraft injected weight is approximately 2450 pounds (1110 kg) and the dry-landed weight is approximately 760 pounds (344 kg).

Three vernier propulsion units are located at the corners of the spaceframe and provide attitude control during retro firing as well as final velocity control. Expected touchdown conditions are within 15 fps (4.92 m/s) vertically and 5 fps (1.52 m/s) horizontally. Shock absorbers in the landing gear and crushable blocks under the spaceframe absorb the touchdown shock.

Figure 1 shows the spacecraft configuration as used on Missions E-J. For Missions K-Q the spacecraft will carry an elevated stereo imaging system and 75 pounds (34 kg) of additional spacecraft-mounted or deployable experiments. The stereo imaging system will be a facimile-type device capable of being elevated to two positions, 30 and 40 feet (9.1 and 12.2 m.) above the surface, to provide vertical-stereo panoramic scanning. This system will be capable of (1) resolving objects 0.1 mm in size at a distance of 3.5 meters, and will have corresponding resolutions at greater distances, (2) obtaining colorometric and polarimetric data, and (3) viewing some of the experiments. An estimated total of at least 600 pictures will be taken as a part of the normal mission operations.

## D. Technical Considerations

All Surveyor spacecraft are expected to be launched and guided to arrive on the lunar surface early in a lunar day. The mission life after arrival on the lunar surface will be limited to the remainder of that lunar day, or a maximum of 14 earth days.

1. Spacecraft Integration

Instruments or equipment proposed to be carried by the spacecraft must be mounted on the space-frame. No booms or other deployment mechanisms are available as part of the basic spacecraft system. The weight of the mounting brackets, booms, orientation mechanism and mounting hardware must be included in the instrument-weight allocation. All experiment packages must be limited to 30 pounds (13.6 kg) maximum weight. Detailed coordination and integration activities with the spacecraft engineering staff will be necessary to ensure that the instrument can be effectively mounted to the spacecraft, determine the specific dynamic loads upon the instrument, ensure that the spacecraft and payload center of gravity is within allowable limits, evaluate the thermal balance between the spacecraft and instrument, and establish the electrical interfaces between the instrument and the spacecraft. These activities are necessary since the Surveyor missions require a high degree of integration between the payload and the spacecraft.

2. Vibration and Acceleration

The spacecraft will be subjected to a static acceleration of 5.9 g during the boost phase and to the mechanical vibrations shown in Table 2. The accelerations (combination of steady state acceleration and superimposed vibration) described are input accelerations to the base of the Surveyor spacecraft. The amplification of these accelerations that experiments mounted at different stations experience depends on the mass of the instrument and its location on the spacecraft. (The amplification factors vary from 4 to 10 for the Mission E-J spacecraft.)

3. Shock

Maximum shock will occur during landing. Shock loads transmitted to scientific instruments will not exceed 40 earth g's for equipment mounted on the spacecraft frame and 70 earth g's for equipment mounted on the landing-gear legs.

4. Temperature and pressure control

Temperature and pressure control will have to be provided for each experiment. In general, each experiment will be exposed to thermal radiation from the sun and the moon, and will radiate to space.

5. Launch Phase

The Surveyor spacecraft is launched into a lunar-transfer trajectory by the Atlas/Centaur booster. The spacecraft is thermally sealed within a conical clamshell-type nose fairing atop the Centaur during the boost phase. A typical transit profile is shown in Figure 2.

## 6. Stabilization

### a. Spacecraft Attitude Control

The Surveyor flight control system maintains the spacecraft in a three-axis stabilized mode using the sun and the star, Canopus, as optical references. Sun sensors and a Canopus tracker provide angular position signals; three gyroscopes provide angular rate signals. These position and rate signals actuate a system of cold gas reaction jets. Alignment is maintained to the spacecraft-sun vector within 0.6° and to the spacecraft-Canopus vector within 0.4° during the earth-moon transit phase except for midcourse maneuvers and descent to the lunar surface.

Spacecraft attitude during midcourse maneuvers and during the retro engine firing is maintained by three liquid-fueled vernier rocket engines, which provide thrust in the direction required for the maneuver. The spacecraft attitude is uncontrolled during the final free fall of about 15 feet (4.92 m) to the lunar surface.

### b. Attitude on Lunar Surface

On the surface the attitude is not controlled but the terrain will be chosen before the mission which, it is hoped, will keep the spacecraft longitudinal axis within 15° of lunar vertical. The attitude on the surface will not be measured, except that some information may be available from the imaging system that will be carried as a part of the spacecraft.

## 7. Power Supply

Electrical power will be supplied to the instrument packages at 29 volts d.c. at a peak power limitation of 50 watts exclusive of start transients. Spacecraft instruments (other than the previously described imaging system) may utilize 500 watt hours per earth day.

During the 2-1/2 earth days on either side of lunar noon at the landing site these rates are reduced to 100 watt hours per earth day maximum. In addition, the high power transmitter may not be operated for other than brief periods (minutes) during this 5 day period.

Included in these rates must be 60 watts for all times that the 10 watt high power transmitter is required for data transmittal and 17 watts for any period that the 0.1 watt low power transmitter is required. Therefore, transmitter power must be subtracted from the instrument power available as a function of the instruments duty cycle.

## 8. Tracking

The world-wide Deep Space Network tracking stations, located at Johannesburg, South Africa, Canberra, Australia, and Goldstone, California, continuously track and maintain communications with the spacecraft during transit and after lunar landing. These stations operate at S-band frequencies via 85-foot (26 m.) and 210-foot (64 m.) diameter parabolic reflector antennas. These stations utilize low noise maser receiving systems, phase-locked to the spacecraft transmitters; they have continuous command capabilities over the spacecraft.

A 210-foot (64 m.) antenna, presently being installed at Goldstone, California, will be available in this time period and could be used for a maximum of 10 hours per earth day.

## 9. Communications and Spacecraft Data Handling

The spacecraft telecommunications system has two redundant S-band transmitters and receivers, capable of independent operation by ground command. The spacecraft receiver-decoder provides command decoding for all spacecraft bus and science subsystems. The spacecraft provides signal processing for a limited number of science instrument parameters. Electrical interfaces between experiments and the spacecraft are handled by an experiment auxiliary built by the spacecraft contractor to meet the instruments functional requirements. The weight required for the auxiliaries must be included in the weight allowance for the instrument. Any data storage requirements must be accomplished by the instrument package(s).

The spacecraft will employ 2 omni-directional antennas and a single high gain planar array directional antenna. The high-gain antenna will be used principally to transmit image data from the spacecraft. The communications system utilizes high power (10 watt) and low power (0.1 watt) transmitters which can be coupled to either the high-gain antenna or an omni antenna.

The following capabilities are available:

### a. Command

Total number of commands available for instruments: 96

Command word length: 24 bits

Command bit rate: 48 bits per second

b. Telemetry

1. General description:

Available bit rates: 17.2, 137.5, 550, 1110, and 4400 bits per second

Encoding accuracy: 10 bits

Word length: 100 or 50 words, dependent upon mode

2. PCM-FM-PM Digital data transmission

Maximum bit rate

| DSIF Antenna | Omni Antenna Spacecraft Transmitter Output Power | | High-Gain Antenna Spacecraft Transmitter Output Power | |
|---|---|---|---|---|
| | 10 watts | 0.1 watts | 10 watts | 0.1 watts |
| 85 foot (26m) | 550 | - | 4400 | 1100 |
| 210 foot (64m) | 4400 | 17.2 | 4400 | 4400 |

c. FM Analog transmission - High-Gain Antenna

| DSIF Antenna | Spacecraft Transmitter Output Power | |
|---|---|---|
| | 10 watts | 0.1 watts |
| 85 foot (26m) | 220 kcps | 2 kcps |
| 210 foot (64m) | 220 kcps | 15 kcps |

10. Ground Data Handling

Ground facilities for data recovery include the standard Deep Space Network S-Band configuration plus a Command and Data Handling Console (CDC) and ground image data system. A 210-foot (64 m) DSIF antenna at Goldstone, California, and 85-foot (26 m) antennas at Canberra, Australia, and Johannesburg, South Africa, will be available for these missions.

The CDC provides all command encoding and subcarrier modulation for the up-link with a command word rate of 2 per second. The CDC also decommutates telemetry for limited local display and for on-site computer editing and formatting for transmission to the Space Flight Operations Facility at the Jet Propulsion Laboratory at Pasadena, California.

The Space Flight Operations Facility provides real and near-real-time data reduction, driving numerous digital printers and analog plotters in parallel with raw or reduced data.

For non-real-time analysis, all incoming data is routed to a disc file for storage until retrieved for the IBM 7094 computer analysis.

## E. Schedule

| Mission | K-N | O-Q |
|---|---|---|
| Proposal deadline | Oct 10, 1965 | Nov 12, 1965 |
| Operating prototype[1] required | Aug 1, 1966 | Apr 1, 1967 |
| Flt quality duplicate[2] required | Oct 1, 1966 | June 1, 1967 |
| Flt quality duplicate[3] required | Jan 1, 1967 | Sept 1, 1967 |
| First Flt unit required | May 1, 1967 | Jan 1, 1968 |

Notes:

1. Operating prototype in flight configuration but not necessarily using flight-quality components, to be used for payload subsystem integration testing.

2. Flight-quality duplicate of flight unit for type-approval testing.

3. Flight-quality duplicate of flight unit for integration into Proof-Test-Model (prototype) spacecraft.

## F. Contact

For further information, please contact Mr. Stephen Dwornik, Surveyor Program Scientist, Lunar and Planetary Office, Code SL, Office of Space Science and Applications, NASA Headquarters, Washington, D. C., 20546.

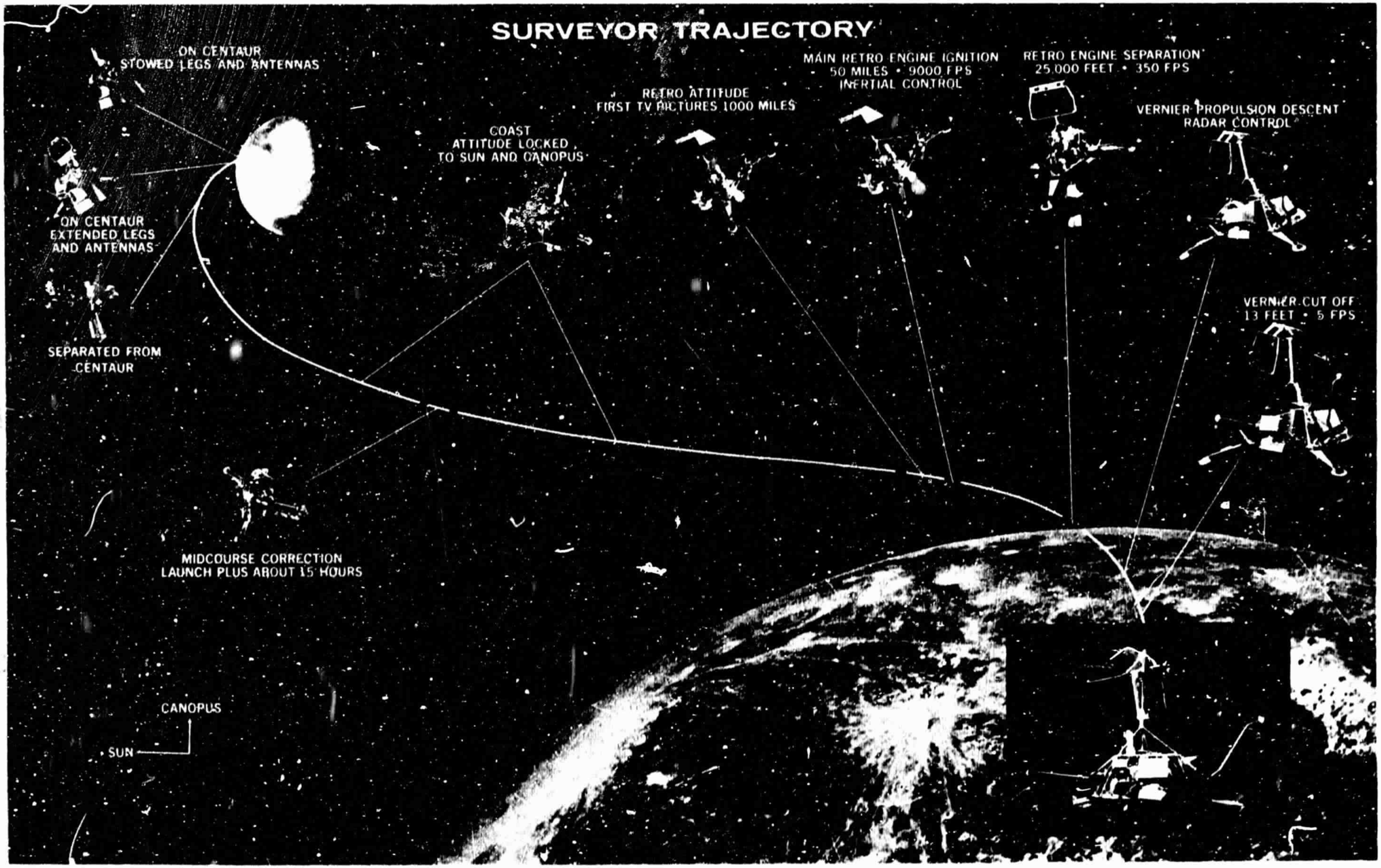



Figure 2. - Typical transit profile.

TABLE 1

LIST OF EXPERIMENTS - SURVEYOR MISSIONS E-I

| Principal Investigator | Experiment Title | Description |
|---|---|---|
| E. Shoemaker (U.S. Geologic Survey) | Television | Two 600 line survey cameras with color and polarization filters, for use on lunar surface. One camera for use during approach. |
| R. Scott (California Institute of Technology) | Soil Mechanics | Device to measure forces and deformations while pressing, dragging, and dropping a clam shell scoop on lunar surface. |
| S. Batterson (Langley Research Center) | Touchdown Dynamics | Gyros, accelerometers, strain gages to measure forces between surface and spacecraft during landing. |
| A. Turkevich (University of Chicago) | Alpha-scattering | Alpha-back-scattering and alpha-proton detectors with pulse height analyzer, for surface elemental analysis. |
| G. Sutton (Columbia University) | Seismometer | Single-axis short-period seismometer. |
| W. M. Alexander (Goddard Space Flight Center) | Micrometeoroid Ejecta | Acoustic and thin-film capacitor detectors, with pulse height analysis. |

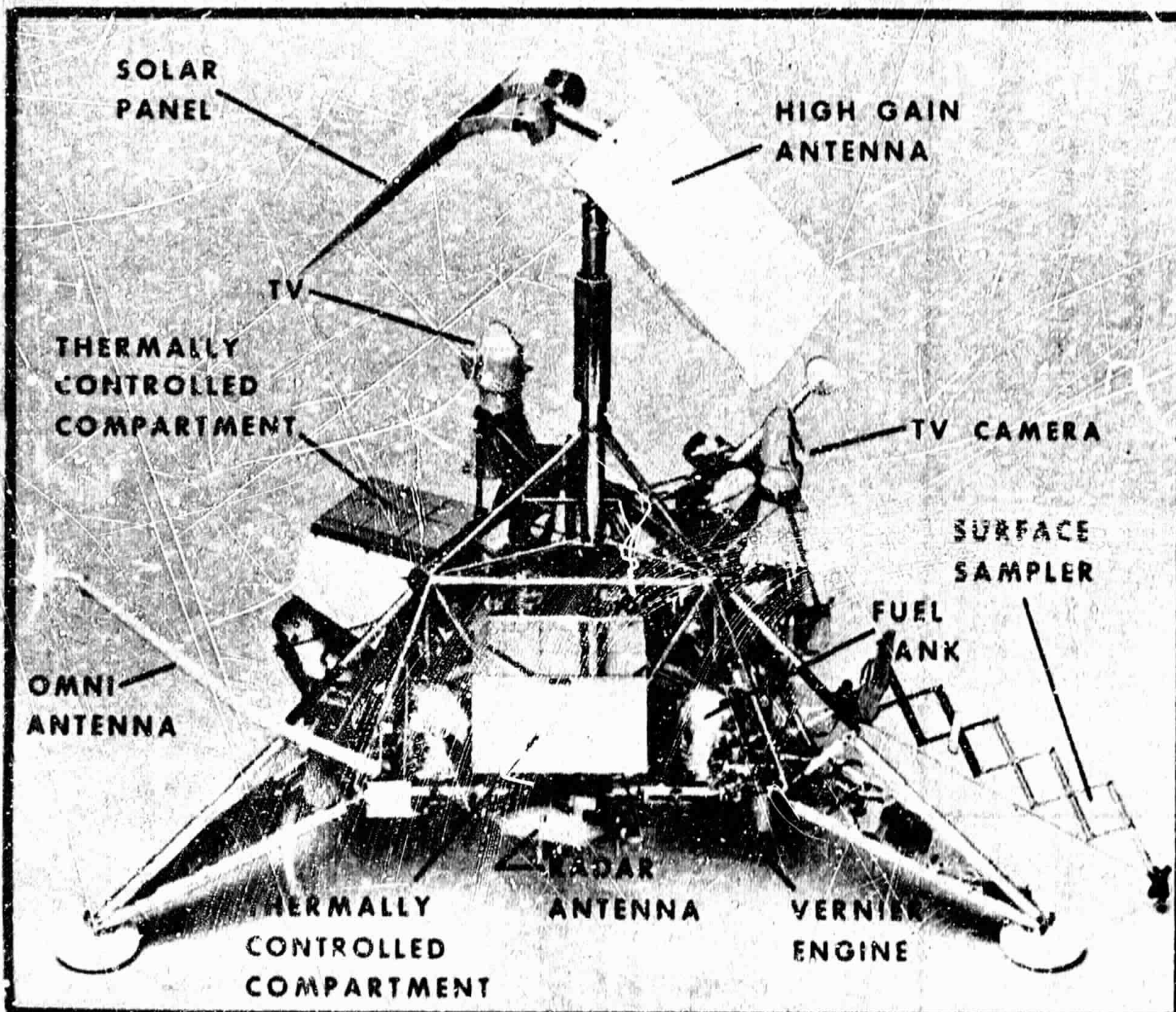
TABLE 2

MECHANICAL VIBRATIONS

AT BASE OF SURVEYOR SPACECRAFT

| Frequency | Level (g) | |
|---|---|---|
| CPS | Longitudinal Axis | Lateral Axis |
| 1 - 5 | - | .275 inch (0.7 cm) displacement, zero to peak, sine wave |
| 5 - 50 | 1.5 | 0.7 zero to peak, sine wave |
| 50 - 1500 | 1.33 | 1.33 zero to peak, sine wave |
| 100 - 1500 | 4.5 | 4.5 rms, white gaussian noise |

# SURVEYOR SPACECRAFT




- **DEMONSTRATE**
  SOFT LANDING TECHNOLOGY
- **SURVEY**
  VARIOUS LANDING AREAS
- **MEASURE**
  PHYSICAL & CHEMICAL PROPERTIES

Figure 1. - Spacecraft configuration used on Missions E-J.

## LUNAR ORBITER SELENODESY PROGRAM

### I. Introduction

The National Aeronautics and Space Administration has initiated an unmanned Lunar Orbiter Program to obtain high resolution photographs of extended areas of the lunar surface for use in selecting suitable sites for future manned landings and selenodetic data to improve our knowledge of the lunar gravitational field. Five Lunar Orbiter spacecraft are scheduled to be placed in close elliptic orbits about the moon in the mid-1966 to mid-1967 time period.

### II. Lunar Orbiter Mission

A typical Lunar Orbiter spacecraft mission will begin at Cape Kennedy. The spacecraft will be boosted and injected into a 90 hour translunar trajectory by an Atlas-Agena launch vehicle. While in transit to the moon the spacecraft will maintain its attitude relative to the sun and the star Canopus and perform one or two midcourse corrections. Upon its arrival in the vicinity of the moon the spacecraft will be injected into a loose initial elliptic orbit about the moon. Because the exact size, shape, and gravity field of the moon is unknown, the spacecraft will be tracked by the Deep Space Network to accurately establish the actual orbit. When the lighting conditions are proper, the spacecraft will be inserted into a final close-in elliptic orbit and pass over target areas at low altitude to obtain the lunar surface photographs. The parameters of the final orbit will have nominal apolune, perilune, and inclination values of 1,850 km, 46 km, and about 14 degrees respectively.

The active lifetime of the spacecraft in its final orbit will be of the order of 12 months. Photographs of the lunar surface will be acquired and transmitted to earth during the first 30 days. During the remaining active lifetime of the spacecraft, the Deep Space Network will obtain accurate range and range-rate radio tracking data for use in determining the influence of the lunar gravity on the spacecraft's orbital parameters.

### III. Lunar Orbiter Selenodesy Experiment

A Lunar Orbiter selenodesy experiment will be undertaken jointly by a team of investigators at the Langley Research Center and the Jet Propulsion Laboratory. The objective of the experiment is the detailed analysis of the radio tracking data by means of sophisticated computer programs to determine the values of the coefficients of the higher harmonics of the lunar gravitational potential.

## IV. Participation

To encourage the broad participation of qualified scientists in the Lunar Orbiter Selenodesy Program, the National Aeronautics and Space Administration plans to make the selenodesy data available at the earliest possible time for use in selenodesy studies concerned with such subjects as lunar theory, lunar librations, lunar gravitational field, the shape of the moon, the mass distribution within the moon, the internal structure of the moon, selenography, and the origin of the moon and earth-moon system.

Proposals for selenodesy studies contributing to a furthering of knowledge of one or more of the above cited subjects are invited. Deadline for proposal submission is September 15, 1965. Notification of action taken on the proposals will be by mid-November 1965.

Selected studies proposed by U.S. scientists will be funded under research contracts with the investigators' institution. Arrangement for the support of studies selected from foreign proposals would be made between the national space organization of the proposing scientist's country and NASA (Office of International Affairs). To insure an integrated selenodesy program of broad scope the investigators will be called upon to serve as members of a selenodesy working team which will meet on occasion to review and resolve problems of mutual interest and to provide technical guidance and assistance to NASA on the planning of future Lunar Orbiter missions.

## V. Contact

Further information can be obtained by contacting:

Dr. Martin J. Swetnick
National Aeronautics and Space Administration
Code SL
Washington, D.C. 20546

# 1971 VOYAGER MISSION TO MARS

The National Aeronautics and Space Administration has initiated the Voyager program for the exploration of the planets, utilizing the Saturn-Centaur launch vehicle. The Voyager spacecraft will be capable of delivering much larger scientific payloads than have heretofore been possible. The first operational mission in the series is scheduled for the 1971 Mars opportunity. It is currently planned to place the spacecraft in orbit about the planet and to land instrumented payloads on the surface.

The primary objective of the 1971 Voyager mission is acquisition of fundamental scientific information concerning the planet Mars. This information will be directed toward elucidation of the physics and chemistry of the planet body, surface, atmosphere, and other environmental parameters, with special emphasis on experiments having biological relevance. Another objective is to further our knowledge of the interplanetary medium through field and/or particle measurements in the space between the orbits of Earth and Mars.

The Voyager program is conceived as a continuing NASA effort to study the planets, and is not confined to the 1971 Mars opportunity, nor to the planet Mars. Subsequent missions to Mars in 1973, 1975, and beyond, are planned. Missions to Venus and to the other planets are also under consideration.

Test flights are planned for the 1969 Mars opportunity. Although the primary objective of these flights is acquisition of information relative to space flight technology, some scientific experiments may also be included. It is intended that whatever experiment complement can be accommodated during these flights shall be selected from among the available experiments on a basis of instrument flight readiness and relative value from the standpoint of contribution to the 1971 mission.

Proposals for scientific experiments contributing to the objectives cited above are invited <u>in preliminary form</u> with a deadline of August 15, 1965. Tentative spacecraft and mission information is provided for this purpose. Proposers of scientific experiments are not required at this time to provide, in firm and final form, all the information regarding their instrumentation that will ultimately be needed for the evaluation and selection of the 1971 Voyager payload. Spacecraft and mission specifications will be defined further and furnished to potential flight experimenters about September 1, 1965. At that time, complete and final proposals will be invited with a deadline for submission of November 19, 1965.

Voyager is planned as the first planetary orbiter and landed capsule mission in our history. It should be borne in mind that the formidable technological problems to be surmounted in entering these totally new areas in the exploration of space necessitate unprecedentedly long lead times for spacecraft design, payload design, integration, and testing. It is for this reason that prospective experimenters are requested to submit preliminary proposals, and that the final proposal deadlines are so far in advance of scheduled launch dates.

## Preparation and Submission of Preliminary Proposals

The preliminary proposals for scientific experiments to be submitted by August 15, 1965, will be evaluated for their scientific merit and technological feasibility. An assignment to a flight mission other than that proposed may be made because of scientific or technical reasons or because space, weight, and/or data capacity requiared for the proposed experiment are not available on the mission for which the investigation was proposed.

The preliminary proposals should contain all of the information requested in the Basis for Selection of Experiments and in the technical and management sections of Proposal Content which is pertinent and feasible to include in a preliminary document. Proposals from domestic sources should be submitted in 15 copies, conspicuously indicating that they are proposed for Voyager 1971, to:

Director, Grants and Research Contracts
Code SC
National Aeronautics and Space Administration
Washington, D.C. 20546

with a request that they be forwarded immediately to the Voyager Program Office, Code SL, Attention Dr. Robert F. Fellows, Program Scientist (Acting). Proposals from foreign sources should be submitted to the Office of International Affairs.

Detailed information regarding costs and schedules for experiments are not required in the preliminary proposals but will be required in the final proposals, due by November 19, 1965.

## Tentative Spacecraft and Landed Capsule Information

For guidance in preparing the proposal, the following tentative information for the spacecraft and landed capsule is supplied. This information should not be construed as representing final design requirements for the Voyager spacecraft or capsule.

It will be noted that ranges have been given for many of the capsule characteristics. Possible capsule capability within such ranges will be strongly affected by the Martian atmospheric properties used for design, the outcome of current development programs in a number of areas of capsule technology, and trade-off consideration that will depend significantly on the nature of the actual scientific payload selected.

I. Lifetime at Mars (design values)
   a. Orbiter: 6 months
   b. Capsule: 2 to 3 days

II. Power available to total science payload
   a. Orbiter: 50 watts, average, during lifetime
   b. Capsule: 25 to 50 watts, average, during lifetime

III. Space available to total science payload
   a. Orbiter: 7 cu. ft. (0.2 cu.m.)
   b. Capsule: 2 to 4 cu. ft. (.055 to .11 cu.m.)

IV. Data storage
   a. Orbiter: $10^8$ bits
   b. Capsule: $10^4$ to $10^6$ bits

V. Data transmission
   a. Orbiter: 1000 bits/sec.
   b. Capsule: 1/2 to 2 bits/sec. (direct)
      10 to 100 bits/sec. (relay)

VI. Weight available to total science payload
   a. Orbiter: 200 lbs. (91 kg)
   b. Capsule: 50 to 100 lbs. (22.7 to 45.4 kg)

VII. Orbital characteristics
   a. Periapsis: 1000 to 4000 km
   b. Apoapsis: 6000 to 40000 km

A scan platform or platforms will be provided for orienting orbiter experiments requiring pointing capability. However, unique pointing or scanning requirements are to be provided by the instruments.

Special mounting situations and hardware may be made available to meet the requirements of various kinds of experiments. For example, a magnetometer may require a boom of a length of three to five times the spacecraft bus main body dimensions. Antennas of up to five times the body dimension may be provided. Unobstructed look angles over a hemisphere or greater of solid angle may be desired for plasma, radiation, and energetic particle experiments.

Weight and power figures suggested above are for experiments only; i.e., sensors, directly associated electronics, power converters and any special mountings required, but not primary power sources, telemetry, or Data Automation Equipment. Experimental measurements must be presented to the DAE in digital form. Advice and assistance in converting analog output to digital form may be rendered by NASA. Sample acquisition equipment may be common to several experiments, and its weight and power requirements must come out of the allotments for experiments.

The data given above are for general guidance in the preparation of proposals, and are not to be considered definitive nor restrictive. Experiments having requirements which deviate from the suggested spacecraft and mission characteristics will be seriously considered, and may be candidates for inclusion in payloads of later flights if they cannot be accommodated at the 1971 opportunity.

One concept of the spacecraft configuration is shown on page 34.

## Conceptual Science Payload

For further guidance, some of the types of experiments which are deemed important are listed in the following section. This list is not exhaustive, and should not be construed as a limitation. Virtually all information concerning a planet may have some biological relevance. As a result, we may require a spectrum of experiments in physics and chemistry, the results of which may contribute eventually to a fairly comprehensive description of a planet rather than a yes or no answer to the question, "Is there life?" For example, physical environmental factors such as the range in surface temperatures and the nature of the atmosphere govern the chemical species and reactions which may exist. Deviations from inorganic equilibrium, such as the presence of mixtures of chemical compounds which in the long run are thermodynamically improbable in the absence of life processes, are of extreme interest. The presence and distribution of atmospheric water vapor and of ground water are of crucial importance. The detection and identification of organic compounds in the surface and subsurface materials may provide vital clues to the chemistry of extraterrestrial life, extant or extinct. Particularly, compounds with functional groups considered important relative to biochemistry such as hydroxyl, amino, phosphate, sulfhydryl, carbonyl, and carboxyl should be sought. The molecular weight range of these compounds may be highly significant. Assessment of stereoisomerism and the predominance of particular stereoisomeric species in families of organic compounds would also be of interest.

Methods which have already shown promise for such studies include fluorimetry, spectrophotometry, and gas chromatography and mass spectrometr both singly and in combination.

Because of the hypothetical nature of our concepts for specific experiment design, there is a rational basis for considering direct visual observation. Not only would such observation on a macro scale allow us to see, and perhaps to recognize as such, organisms which have evolved past the micro-organismic stage but it might well be crucial in interpreting the results, or lack of them, from other experiments.

Microscopic observations of selected and/or processed samples in both the visible and infrared are suggested as possible eventual refinements.

General areas of experimentation are presented in outline form below:

I. Martian Orbiter Experiments

a. Atmosphere studies (chemical composition, temperature, and pressure and their diurnal variations, scale height, circulation patterns).

b. Planetary studies (gravitational and magnetic fields, mapping in the visible and infrared, topography).

c. Planetary environment (radiant energy spectrum, charged particle energy and density, micrometeoroid flux).

II. Martian Lander Experiments

a. Atmosphere studies (complete chemical analysis, vertical temperature and pressure profiles, wind velocities).

b. Planetary studies (chemical composition of crust material, mineralogy, seismology, touchdown dynamics, radioactivity).

c. Actinic radiation (flux and energy spectrum of radiant and particulate penetration to the surface).

III. Interplanetary Space Experiments

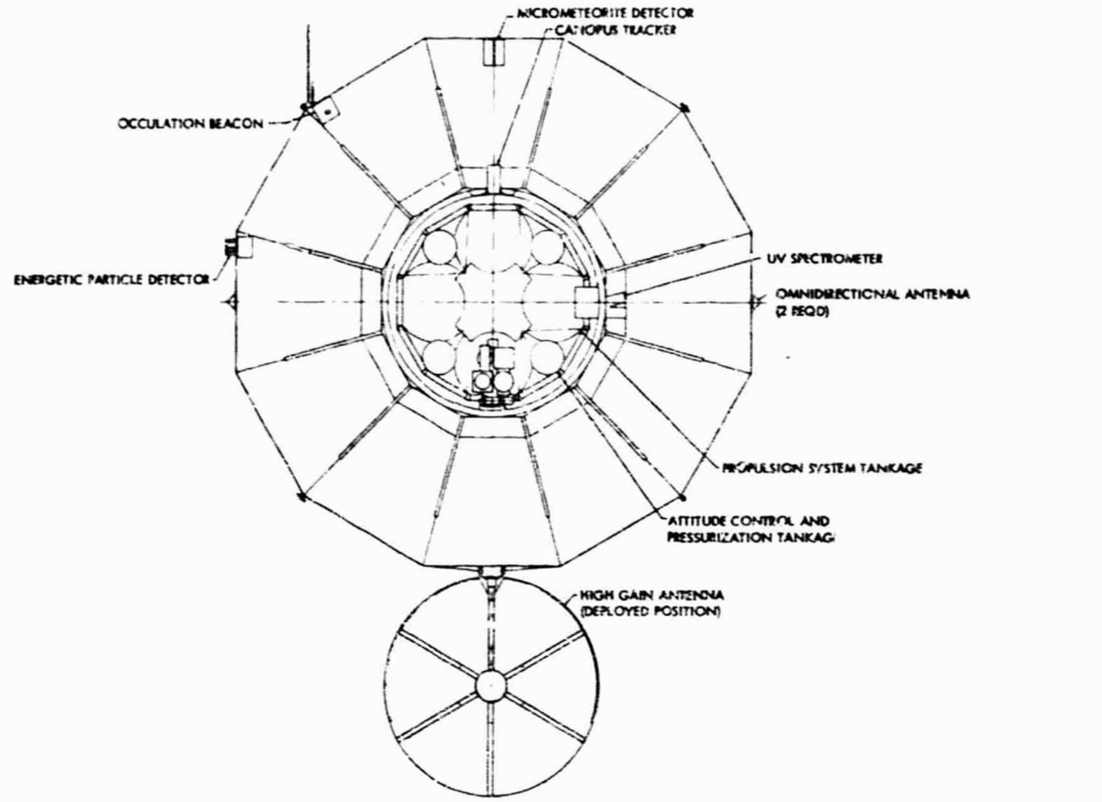
(cosmic radiation, solar plasma, magnetic fields, micrometeoroid flux).

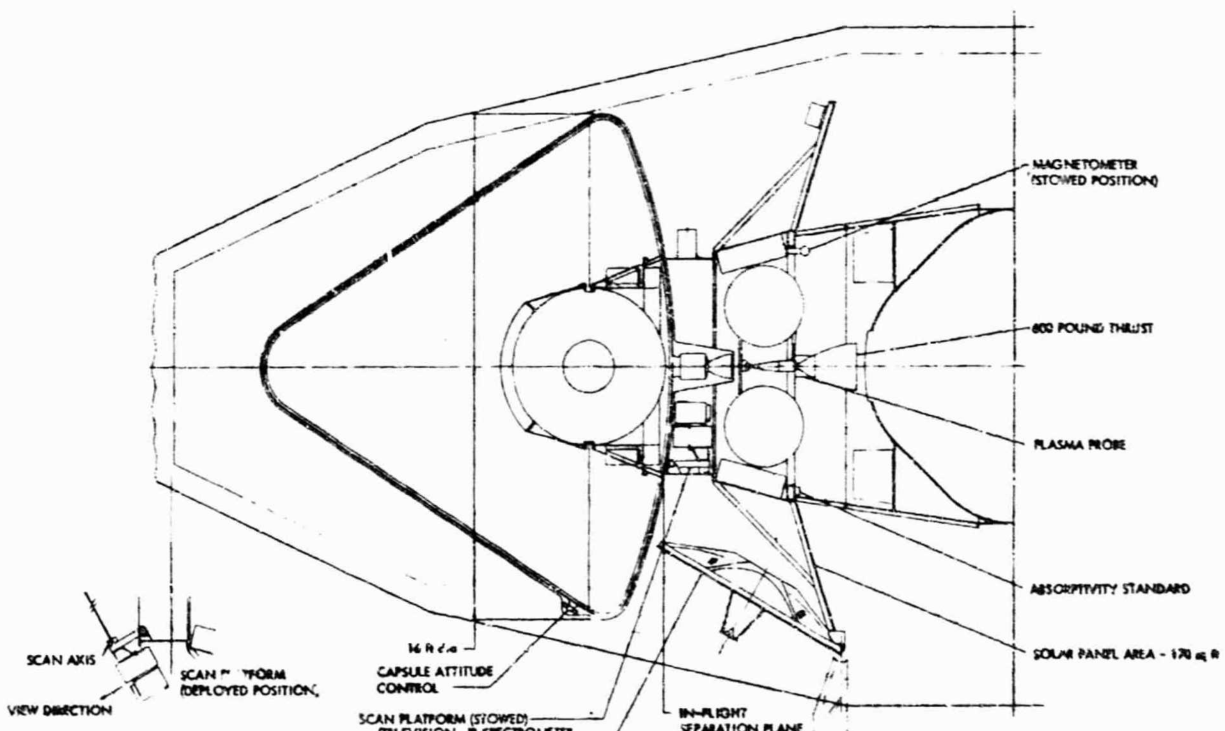
All Voyager 1971 experiments must meet planetary quarantine constraints. Landed capsule experiments must meet stringent sterilization requirements. Advice and assistance in meeting sterilization requirements will be rendered by NASA to prospective flight experimenters.

As stated earlier, the 1971 Voyager mission is the first in a series, and cannot be expected to completely accomplish the program objectives. Advancing technology and experience will enable the accommodation in later missions of larger and more complex experiments than are feasible in the

1971 time period. The sooner such experiments are submitted for consideration, the better their prospects for flight at the 1973 and subsequent opportunities. Therefore, prospective experimenters are urged to submit proposals even though the probability of their inclusion in the 1971 mission may seem low.

The generation by the National Aeronautics and Space Administration of a logically expanding program of scientific exploration of the planets will be facilitated by early guidance from the scientific community regarding the types of experiments they wish to perform.




One Concept of VOYAGER Configuration for Study

# TIROS

## Introduction

Objective: To utilize the proven design of the basic TIROS spacecraft with minor modifications as appropriate to gather data primarily for meteorological purposes. Such uses include the flight testing of advanced sensors having potential use in the TIROS Operational Satellite (TOS) System. These sensors would be designed primarily to meet the evolutionary requirements for the TOS System; i.e., local as well as remote coverage of cloud data both day and night. Other uses include possible singular experiments to fulfill special data requirements of the meteorological research community.

Orbit Considerations: Spacecraft launched for flight test of advanced sensors for TOS will be placed into circular, near-polar, sun synchronous orbits at altitudes of approximately 750 N.M. (1390 km).

Other orbits with inclinations of 48° and 58° and at altitudes of approximately 400 N.M. (740 km) have been flown. Missions with other inclinations and with various eccentricities can also be considered.

Orbital Lifetime: The expected lifetime of each satellite is estimated to be six months; however, lifetimes of one year and more have been achieved.

## Spacecraft Body

The TIROS satellite is an 18-sided polyhedron resembling an oversized hat box. It is 22 inches (0.56 m) high, and 42 inches (1.07 m) in diameter. The majority of the components are mounted on a reinforced baseplate. The nominal weight of the spacecraft with sensors is 285 pounds (1.29 kg). The sensors are normally aligned to view either through the bottom of the spacecraft, or through the rim of the spacecraft.

## Payload Environment

Since TIROS is not of modular construction, specific size, weight, and volume restrictions for individual payloads cannot be stated. However, the over-all size of the spacecraft can be used as a guide in considering potential payloads.

The expected vibration and shock environments are as follows:

| | |
|---|---|
| Longitudinal acceleration | 50 g steady state |
| Transverse acceleration | 30 g steady state |
| Vibration in three planes | 7 g rms, 20 to 2,000 cps |

Temperature control of the spacecraft is accomplished by passive techniques which involve utilization of proper absorptivity/emissivity ratio surfaces and coatings, construction techniques and material selection that provide a suitable heat flow pattern, and solar cell filters. The expected temperature variation lies between $0^{\circ}$ C and $50^{\circ}$ C.

Accurate estimates of electrical power available for experiments cannot be made at this time; however, experimenters may use the over-all power system description given below as a guide.

## Launch Phase

The TIROS satellites will be launched on the basic Delta launch vehicle or an advanced version of the Delta launch vehicle.

## Stabilization

The present TIROS is spin-stabilized having a spin rate of 9 to 12 rpm.

Attitude determination is accomplished with horizon scanners and through analyses of received TV pictures. Attitude control is accomplished with the use of an attitude control coil energized by the satellite's power supply.

## Power Supply

Electrical power is supplied by approximately 9200 solar cells mounted on the top and sides of the spacecraft. To maintain a continuity of power, 63 nickel-cadmium storage batteries are used. The total average available power is 20-watts at 24.5 volts nominal.

## Tracking

Two tracking beacons operating continuously at nominally 136 MC will be used for tracking purposes. The STADAN network will be utilized for orbital determination. Command Data Acquisition (CDA) stations located at Wallops Island, Virginia, and Fairbanks, Alaska, will be used for programming the satellite and for data retrieval.

## Communications

The following types of transmitters will be carried aboard the spacecraft:

| | |
|---|---|
| Tracking and telemetry | 136 MC, 50 MW |
| TV Transmitters (2) | 235 MC, 2W |
| IR Transmitter | 237 MC, 2W |

The following antenna systems may be used:

| | | |
|---|---|---|
| Transmitting | - | Two crossed dipoles fed in quadrature |
| Receiving | - | Quarter-wave monopole |

<u>Contact</u> - Mr. Michael Garbacz
Program Manager, TIROS/TOS
Office of Space Science and Applications
NASA, Washington, D.C., 20546

# NIMBUS

## Introduction

Objective: To develop a series of significantly improved meteorological satellites to provide data for use by meteorologists; to carry out flight tests to prove the applicability of the instrumentation; to fulfill special data requirements of the atmospheric sciences research community which can be provided uniquely by this instrumentation functioning as a space meteorological observatory, and to provide the bases for further significant technological advances in meteorological satellites for operational as well as scientific uses.

Planned Launches: The present Nimbus Program consists of four planned launches, one of which, Nimbus I, was successfully launched on August 28, 1964. The remaining three will be launched approximately 18 months apart starting in FY 1966, and will consist of the launch of Nimbus C followed by Nimbus B and D spacecraft.

Brief General Description: Nimbus is a three-axis, earth-stabilized spacecraft that will provide full earth coverage on a daily basis by means of a near-polar orbit having an inclination of approximately 80° to the equator. The earth's rotational movement provides the mechanism for longitudinal coverage while latitudinal coverage is obtained by the spacecraft's orbital motion. The satellite consists of three major subsystems--power, stabilization, and the sensory ring which is capable of accommodating a variety of advanced sensors.

Orbital Characteristics: A "high noon" nearly circular 80° retrograde orbit of approximately 600 to 750 N.M. (1110 to 1390 km).

Expected Lifetime: Six to twelve months.

Spacecraft Body:

Structure:

Weight: 830 to 1,250 pounds (376 to 567 kg).

Dimensions: 10 feet (3.05 m) high x 10 feet (3.05 m) wide with paddles extended; sensory ring, 57 x 13 inches (1.45 x 0.33 m); control housing, 17.25 x 33.28 inches (0.44 x 0.85 m); truss separator, 48 inches (1.22 m); solar paddles (each) 3 x 8 feet (0.91 x 2.44 m).

Viewing Angles

The satellite will always view the earth at near local noon on the sunlit side and near midnight on the dark side.

## Payload Environment

### Physical Characteristics

The sensory ring subsystem is a toroid with a 57 inch (1.45 m) outside diameter, 40 inch (1.02 m) inside diameter and 13 inch (0.33 m) depth. The assembled ring structure forms 18 module centers measuring 8x6x13 inches (20x15x33 cm). The design permits the structure to accommodate eight different sizes of modules which can be top or bottom loaded. The structure weight is approximately 175 pounds (85.5 kg).

### Acceleration

| | |
|---|---|
| Longitudinal | 15 G steady state |
| Transverse | 3 G steady state |

### Vibration

Up to 5 G in one direction along the thrust axis and at 0.5 G in both directions along each of the transverse axes in the frequency range of 5 to 2,000 cycles/second.

### Temperature Control

The Nimbus design uses both active and passive controls to achieve a thermal environment in which sensors and experiments will perform, with a minimum of degradation, for the 6 months' spacecraft life. The sensory ring subsystem temperature is stabilized to 25 ± 10° C.

### Launch Phase

Type of Vehicle: Thrust-Augmented Thor-Agena

Launch Facility: Western Test Range

Time: Approximately midnight

### Stabilization

Methods involved in stabilization: Basically the Nimbus active stabilization and control system employs a rate gyro, three fly wheels, and eight freon gas nozzles as torque generators to provide attitude control of the spacecraft. A pneumatic tank located under the control housing contains the nitrogen gas supply. The nozzles function to reduce large stabilization errors, while the fly wheels compensate for small errors. It is planned to employ both active as well as passive gravity gradient stabilization systems in the advanced Nimbus D spacecraft.

## Power Supply

Methods of power generation and storage: Combination of silicon solar cells and nickel-cadmium storage batteries for the first flight spacecraft. The Nimbus B and D spacecraft will be supplied with auxiliary nuclear power supplies of at least 50 watts' output.

Total capacity at rated voltage and power: -24.5 V.D.C. ± 2%, 300 watts average power (includes at least 50 watts available from the nuclear power supply).

## Tracking Stations

| Location | Type |
|---|---|
| Fairbanks, Alaska | Data Acquisition Center |
| E. Grand Forks, N.D. | Minitrack |
| Mojave (Goldstone Lake) | Minitrack |
| Fort Myers, Florida | Minitrack |
| Quito, Ecuador | Minitrack |
| Antofagasta, Chile | Minitrack |
| St. Johns, Newfoundland | Minitrack |
| Lima, Peru | Minitrack |
| Blossom Point, Maryland | Minitrack |
| Santiago, Chile | Minitrack |
| Winkfield, England | Minitrack |
| Johannesburg, S. Africa | Minitrack |
| Woomera, Australia | Minitrack |
| Rosman, North Carolina | Data Acquisition Center |

## Data Handling

Meteorological and engineering data transmitted by Nimbus satellites will be received and processed at the Acquisition Centers and will be relayed over wideband communications lines to Goddard Space Flight Center. Engineering data will be examined both at the Acquisition Centers and at GSFC to determine the functional status of the satellites. Scientific data will be processed with a minimum of delay and made available to the various experimenters in the format desired by them. Where feasible and desirable, the data will be analog form for quick-look by the experimenter and for the spacecraft evaluation.

## Communications

### Command Functions

A total of 128 different functions can be commanded through this system. Commands can be transmitted to the spacecraft, stored and executed up to twenty-four hours later.

Antenna Systems

| | | |
|---|---|---|
| VHF Tracking and telemetry | : | 4 phased quadraloop antennas |
| S-Band telemetry | : | 1 conical spiral antenna |
| Interrogation | : | Folded ground plane on top of control housing |

Transmission System

| | | |
|---|---|---|
| VHF Tracking and telemetry | : | 136 MC (Nom); PCM/AM 350 milliwatts |
| S-Band telemetry | : | 1,705 MC (Nom); FM 4 watts |

Experiments

Some of the experiments for the Nimbus Program have already been selected.

A. Nimbus C

The payload complement for Nimbus C is complete and includes the following:

1. Advanced Vidicon Cameras
2. Automatic Picture Transmission (APT) System
3. High Resolution Infrared Radiometer with Direct Readout to APT Ground Stations
4. Digital Medium Resolution Infrared Radiometer

B. Nimbus B and D

Among the experiments well enough established to be considered for Nimbus B and D are the following:

1. Infrared Interferometer Spectrometer
2. Interrogation, Recording and Location System
3. Medium Resolution Infrared Radiometer
4. Solar Ultra Violet Experiment
5. Satellite Infrared Spectrometer
6. Microwave Radiometer
7. Sferics
8. High Resolution Infrared Radiometer
9. Weather Data Relay
10. Cameras (Automatic Picture Transmission and Advance Vidicon Camera System, Dielectric Tape Camera, Day-Night TV Camera, and Continuous Mapping Cameras).

In addition to the above, it is anticipated that other meteorological experiments may be accommodated on Nimbus spacecraft in 1967.

For further information contact Dr. Richard Haley or Mr. Richard Kee, Meteorological Programs Division, Office of Space Science and Applications, NASA, Washington, D.C. 20546.

## INTERROGATION, RECORDING, AND LOCATING SUBSYSTEM (IRLS)

### Introduction

The major objective of the IRLS experiment, a subsystem which will be flown on board the Nimbus series of spacecraft, is to establish the feasibility and to fully test out the capability of a satellite to collect data from sensor platforms, both fixed and moving, which are immersed in the atmosphere and on the earth's surface. A full description of the Nimbus series of spacecraft will be found elsewhere in this document.

### Brief Description

The IRLS system is designed with the capability of interrogating and locating the platforms and then recording the data collected by the sensor platforms. The IRLS, using a programmed approach, will interrogate and locate platforms and then store the data. At the proper time, this data will be read out by CDA stations. It is anticipated that meteorological data so collected will be useful in numerical weather prediction and will help the early realization of long range weather predictions.

### Sensor Platforms

The inclusion of IRLS as an opportunity for experiments is to encourage the participation by experimenters and/or government agencies in the development and distribution of instrumented platforms which will work with IRLS. Each platform is to include an IRLS transponder for contact with the satellite. A matching network will be required to provide input to the IRLS transponder.

Experimenters will be required to furnish the complete platform including the sensors, the sensor matching network, and IRLS transponder packaged for the platform environment, and a source of power (10 w continuous @ -24 v D.C.) which will supply the necessary power for the IRLS transponder. The IRLS transponders will not be limited to balloon and buoy application alone, but may also be designed for use on aircraft, ocean surface vessels, and remote automatic land stations. The maximum data bit rate which the IRLS transponder will accept is 1,000 bits/sec. The input power requirement may be lowered significantly as the design of the transponder is optimized.

While the preliminary purpose of this experiment is to collect meteorological data, the collection of other data such as oceanographic data is not precluded.

For further information, contact Mr. Louis B. C. Fong or Mr. Richard G. Terwilliger, Meteorological Programs Office, Office of Space Science and Applications, NASA, Washington, D.C. 20546.

The X-15A2 research airplane is a modified version of the standard X-15, which has reached altitudes of 350,000 feet. The newer version will be above about 200,000 ft. for about two minutes.

The X-15 airplane provides a unique vehicle for scientific payloads. Recovery and immediate availability of the payload is, of course, provided. The flights must be made in the vicinity of the NASA Flight Research Center, Edwards Air Force Base, California, and because of safety and landing considerations are restricted to the daylight hours. Flights recur on a regular basis and, therefore, proposals are acceptable at any time. The pilot is available on a limited basis to aid the experimenter.

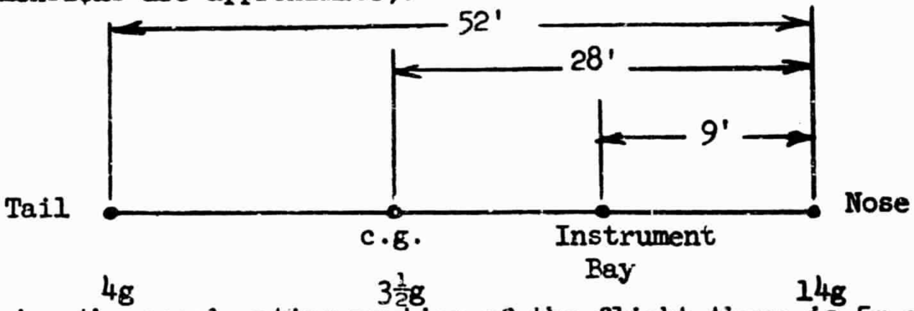
## Main Instrument Bay

### Vibration

For flight qualification experiments would be subjected to vibrations of 3g, at frequencies between 40 and 150 cps to a double amplitude of 0.036"; at 0.41g between 10 and 15 cps; and finally with a double amplitude of 0.08" at frequencies between 5 and 10 cps. The complete experimental package must have no natural frequencies less than 10 cps.

### Shock

The maximum shocks experienced during normal landings are as shown (all dimensions are approximate):




During the accelerating portion of the flight there is 5g acting vertically on the pilot's seat and [illegible]g perpendicular to the pilot's backrest. The airplane structurally is designed to withstand 11g on each of the three mutually perpendicular axes.

### Temperature

The instrument bay which is located aft of the cockpit has doors (flush with the top of the fuselage) which can be opened or kept closed. In the open position the instruments should be designed to withstand temperatures ranging from -70°F to +160°F. If the experiment can be operated with the

doors always closed then the instrument bay is pressurized with nitrogen to $3\frac{1}{2}$ lbs. psia. and the temperature ranges from -40°F to +130°F.

### Electric Power

Electric power available to the instrument bay is 115/200 volts AC; three phase: 300 cps. The voltage is regulated to within ± 1.1 volts and the frequency to within ± 4 cps. 28 volts DC ± 4 volts is available and up to 1000 watts may be available depending upon the particular time requirement.

## Tail Cone Box

The tail cone box is located immediately aft of the vertical tail fin and measures about 20" left to right, 19" top to bottom, and 13" front to back. It is not temperature controlled and there is no internal pressure. The box is lined with one inch of fiberglas insulation and normally it is exposed to the elements.

## Stable Platform

The airplane is equipped with a stellar inertial platform employing an inverted gimbal arrangement on a stabilized platform and an automatic star tracker. A ground support console forms part of the system and provides complete alignment and check out capability of the system. Specifically this system contains a three axis gyro stabilized inertial platform with an optical acquisition and tracking ability capable of positioning a payload to an accuracy of well within one minute of arc. It is designed to operate while exposed to space environments in flight. Payloads of about 90 lbs. in a volume of 1 3/4 cubic feet are provided for. The design facilitates placing the payload external to the supporting gimbals which gives an unobstructed field of view of well over ± 90° in all directions from the central pointing axis. Orientation information is available from synchros located on each of the gimbal axes. These signals can be used to actuate the vehicle through a suitable control system or pilot display so that in situations where it is necessary vehicle orientation with respect to the platform axes can be maintained accurately. Input command channels are available to permit slaving the system to any master control system. The stable platform is located in the main instrument bay.

For more information on either the X-15A2 or Stable Platform please contact Mr. Ernest J. Ott, Code SGA, NASA Headquarters, Washington, D. C., 20546.

# CONVAIR 990A RESEARCH AIRPLANE

## INTRODUCTION

The Convair 990A is a four-engine, high altitude, long-range, high speed jet transport airplane. It is effectively a manned laboratory with the capability of carrying bulky and heavy observational instruments and equipment for making airborne scientific observations. The aircraft is based at the NASA Ames Research Center, Moffett Field, California. The airplane may be flown to and operated from an advanced base nearly anywhere in the world. Depending upon the mission to be flown, and the payloads involved, the aircraft should be capable of operation from virtually any airport which normally serves four-engine jet aircraft. The aircraft time will be used for both space science and aeronautical research projects.

## Aircraft Body

### Overall Characteristics:

The aircraft possesses some basic features, as well as certain modifications which may be valuable for various prospective experiments. Initial modifications to the airplane have been made to accommodate the 1965 solar eclipse experimentation, and much of this equipment will be retained to serve future requirements.

The approximate cabin dimensions, with all seats and equipment removed are: 28.0m(92 feet) long x 3.2m(10.5 feet) wide x 2.1m(82 inches) high (for distance from floor to center of observation window, and also for distance from center of floor to bottom of air conditioning duct). Two lavatories, one in either end of the cabin, are installed: one is to be used as an on-board photographic darkroom. There are about 40 seats to accommodate the experimenters during take-off, landing and enroute portions of the flight.

The maximum cruising speed is 1000 Km/hr (620 miles/hr., 540 knots). The cabin is pressurized to about 2.5 Km (8000 feet) when the aircraft is at 12-13 Km (40,000-43,000 feet) altitude.

### Structural Features and Viewing Angles:

Among the airplane features of special importance are the following:

43 passenger windows, right side of cabin; 46 passenger windows, left side of cabin. Elevation angle: 14°. Double plexiglas, untinted; approximately 25cm (10") wide x 36cm (14") high, and about 50 cm (20") apart, on centers. Transmissivity curves are available.

The timing system consists of:

Time-code generator and digital clock with visual readout (at coordinator's console) of absolute time to milliseconds. This may be relayed to the experiment stations in any of four modes: (1) Time of day in hours, minutes, seconds (Binary-coded decimal system contained within a time frame of one second), carried on a 1 kc AM signal ... interpolation to $10^{-3}$ sec.; (2) Parallel BCD of hours, minutes, seconds, milliseconds, and 0.1 milliseconds, signal levels are 6v to 15 v, and capable of driving a load of 5000 ohms to ground; (3) Serial time code output which provides an AM 1kc signal of about 10v amplitude for a mark and 3.3 for a space; and (4) Pulse rates available at 1, 10, 100 and 1000/sec., output amplitude of 6 v to 15v. (The reference for this time code generator and clock is an internal oscillator accurate to 1 part in 10 .

## Contact

Proposals should be submitted to the Office of Grants and Research Contracts. Financial support of proposals and recommendations for aircraft flight is the responsibility of cognizant NASA programs.

The OSSA representative for the Convair 990A is Maurice Dubin, Code SG, NASA Headquarters, Washington, D.C. 20546.

# OSSA SCIENTIFIC BALLOON PROGRAM

The Office of Space Science and Applications (OSSA) supports a program of balloon flights to carry a variety of scientific instruments into space. Areas of interest to the OSSA are:

1. Aeronomy
2. Solar Physics
3. Astronomy
4. Energetic Particles and Magnetic Fields
5. Micrometeoroids and Cosmic Dust
6. Planetary Observations
7. Biology

There are a number of balloon launch sites available to NASA experimenters. Sites under which NASA has arrangements for balloon launches and recovery operations are:

Fort Churchill, Canada -- Launches conducted during June-September.

Flin Flon, Canada -- Launches conducted during June-September.

Palestine, Texas -- Launches conducted all year.

Page, Arizona -- Launches conducted all year.

If the above sites are not satisfactory then NASA can make arrangements for other launch areas in the U. S. or in foreign countries. If the experimenters desire, they may conduct their own balloon launches upon meeting the Federal Aviation Agency and Federal Communication Commission approval.

A payload vs altitude curve for various balloon sizes is shown in Figure 1.

Equipment needed for determining balloon altitude and orientation will be provided. Telemetry equipment can be provided if desired. A FM/FM telemetry system is most commonly used.

Proposals should contain a technical description of the experiment and an outline of its scientific objectives. The present status of the proposed technology should be discussed, as should any unusual requirements which the experiment places on the balloon flight system. Additional information should include the number of flights, the time period, the desired launch site, and in the case of U. S. experimenters, the needed

government-furnished equipment. An estimate of the funds required to furnish the instrument and analyze the resulting data should be included in the proposal.

For further information concerning the scientific balloon program, please contact Mr. John R. Holtz, Code SGX, Physics and Astronomy Programs, NASA Headquarters.

## LOAD vs. ALTITUDE

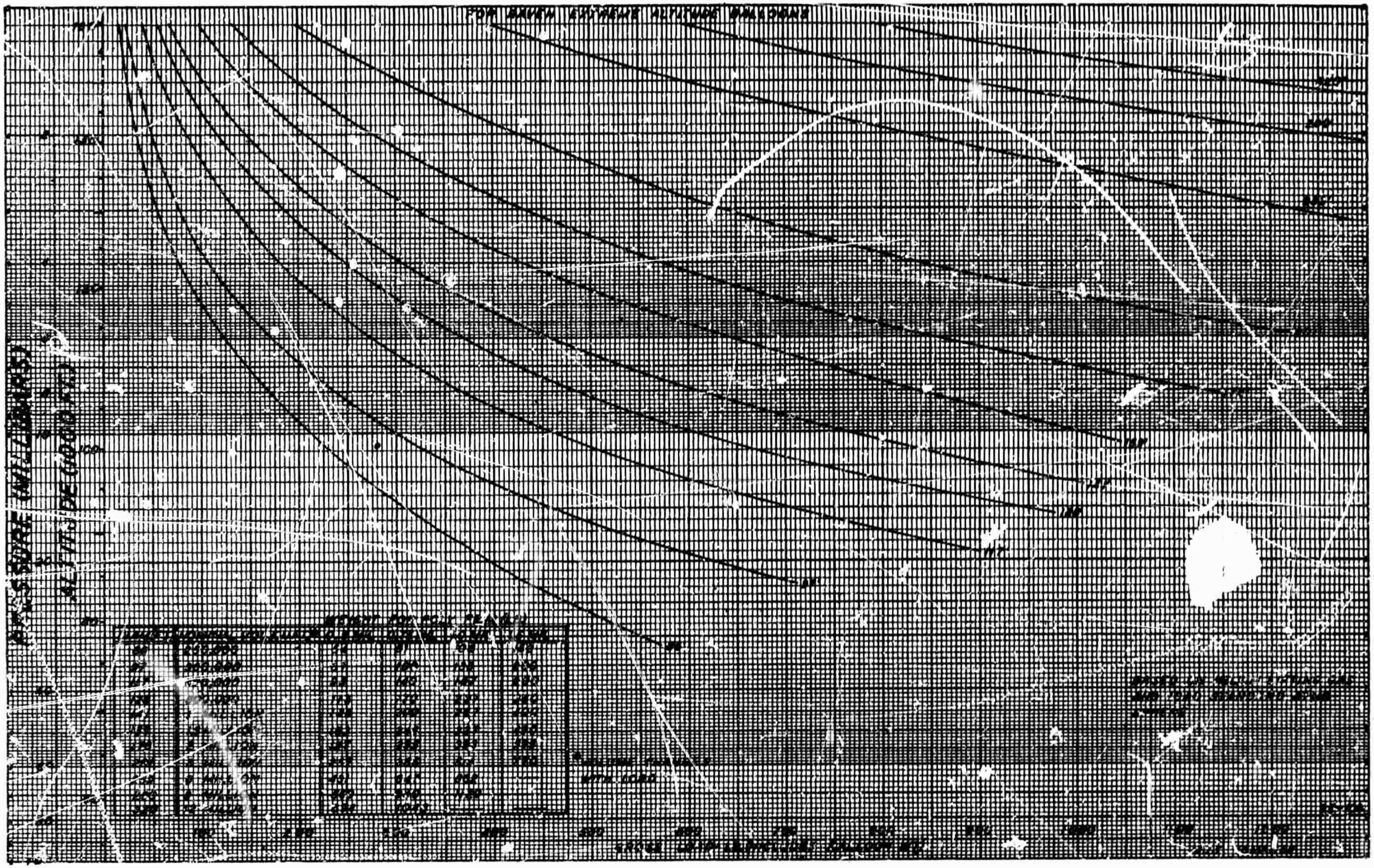



FIGURE 1

# INTERNATIONAL SATELLITES FOR IONOSPHERIC STUDIES (ISIS)

The ISIS series consists of three satellites, ISIS-A, ISIS-B, and ISIS-C to be launched as part of a joint Canadian/US program in ionospheric research. The scientific objective of each satellite in this series is to obtain a coordinated set of ionospheric measurements, with particular emphasis on the F region, its constitution, structure and special features. The payload for ISIS-A has already been selected, and Canada is expected to provide a Topside Sounder for ISIS-B. Experiments are invited which may appropriately be performed in conjunction with the Topside Sounder on ISIS-B. The Canadian Defence Research Board and NASA will review and evaluate all the proposals. A joint DRB/NASA committee will make the final selection of the supporting experiments. Highest priority for payload selection will be given to those experiments of proven capability which will aid in our understanding of the ionosphere and which are best suited to this series of satellites. To obtain the maximum value from this coordinated series of measurements, the principal investigators will be expected to make their data mutually available and to participate in the meetings of the ISIS Working Group before and after launch of the spacecraft.

In order to be considered for the ISIS-B flight, scheduled for late 1968, the proposals for supporting experiments must be received by 1 January 1966. Proposals originating in the U.S. should be submitted in accordance with procedures outlined in the Introduction. Since this is a joint Canadian/US program, experimenters in Canada should send thirty (30) copies of their proposal to the Director of Physical Research, Defence Research Board, Headquarters, DMD, Ottawa 4, Canada. Proposals from outside the U.S. and Canada should be submitted to the Office of International Affairs, Code AI, NASA Headquarters, Washington, D. C. 20546.

Consideration is presently being given to an elliptical orbit, perigee 300 km, apogee 4000 km, and inclination 80°. Since these parameters may be varied in accordance with the needs of the experimenters or the results from earlier satellites in the series, proposals should contain a discussion of optimum orbital requirements, and acceptable compromises. To provide information on some approximate characteristics for future ISIS satellites, the ISIS-A specifications are given on the following page.

For further information please contact Mr. Raymond Miller, Code SG, NASA Headquarters, Washington, D.C. 20546.

# ISIS A

## Satellite Characteristics

### Orbit

| | |
|---|---|
| Apogee | 3500 $\pm$ 1000 km |
| Perigee | 1000 $\pm$ 500 km |
| Inclination | 80° Prograde |

### Spacecraft Stabilization

Spin stabilized 1 to 3 rev/min

### Spacecraft Attitude Sensing

3 axis magnetometer
Solar Aspect Sensor

### Power Supplies

11,136 n-on-p 10-1/4% (A.M.O.) efficiency solar cells will charge NiCd batteries.

Operational time after 1 year, 4 hours per day (i.e., 320 watt/hours per day)

Continuous operation: Two consecutive pole-to-pole passes

### Command

Multiple tone-digital system.

### Programmer

Will permit storage of 5 commands. Each command may be selected from a group of 10.

### Tape Recorder

35 kc/s bandwidth. 1 hour record time.
Playback in 12 mins.

### Telemetry

100 kc/s channel at 136 mc/s
50 kc/s channel at 136 mc/s
500 kc/s channel at 400 mc/s

# UNSCHEDULED EXPLORERS

Explorers are small satellites designed to carry specific groups of experiments into orbits especially selected for the experiments involved. They are primarily utilized to explore the earth's atmosphere, ionosphere, magnetosphere, and the near earth region of interplanetary space. They are also employed in international cooperative programs.

These spacecraft can be placed into a variety of eccentric and circular orbits at inclination angles ranging from polar to very low inclinations. The Scout, Delta and Agena class launch vehicles will be utilized to achieve these orbits.

In addition to opportunities for submission of individual experiments for the planned Explorer spacecraft, opportunities also exist for consideration of experiments whose requirements are not met by the presently scheduled flights. Investigators are encouraged to submit proposals of scientific merit and technical feasibility (1) for experiments which have special requirements and (2) for the design and construction of complete payloads comprised of experiments having special requirements. NASA will also give full consideration to the assignment and development of entire spacecraft by individual organizations in industry, and by universities, NASA field centers, other government agencies, and foreign research organizations.

For additional information concerning these projects please contact Mr. M. J. Aucremanne, Program Manager, Explorers and Sounding Rockets, Physics and Astronomy Programs, Office of Space Science and Applications, NASA Headquarters.

## SOUNDING ROCKET PROGRAM

The National Aeronautics and Space Administration is currently conducting research with sounding rockets in the following disciplines:

1. Aeronomy
2. Solar Physics
3. Astronomy
4. Energetic Particles and Magnetic Fields
5. Micrometeorites and Cosmic Dust
6. Planetary Observations
7. Biology

The presently available rockets, their performance capability, and the general dimensions of the corresponding payload compartments are shown in Section I.

Launching sites in the U. S. are shown in Section II, along with sites elsewhere which possibly may be available to U. S. experimenters through cooperative international arrangements.

Section III lists flight hardware which can be furnished to U. S. experimenters and which may be available to foreign experimenters as part of cooperative arrangements.

Proposals should contain a technical description of the experiment and an outline of its scientifi objectives. The present status of the proposed technology should be discussed, as should any unusual requirements which the experiment places on the flight system. Additional information should include the number of flights, the type of vehicle, the time period, and the launch site desired, and in the case of U. S experimenters, the government-furnished equipment and funding required.

For further information on the Sounding Rocket Program, please contact Mr. John R. Holtz, Code SGX, NASA Headquarters, Washington, D. C. 20546.

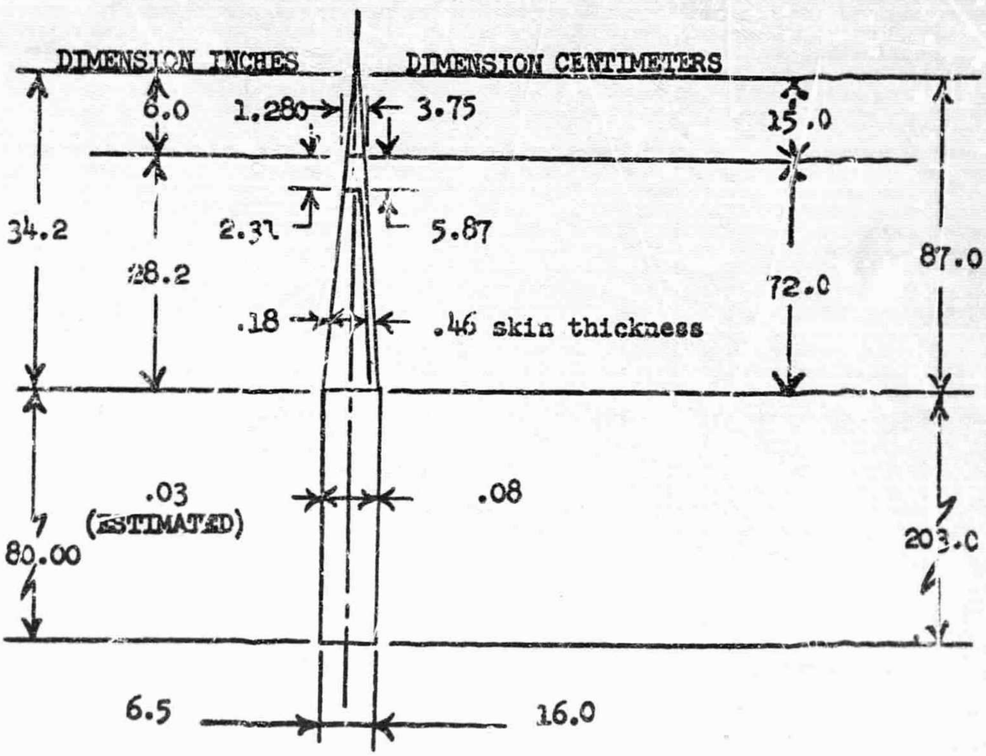
SECTION I

## VEHICLE PERFORMANCE CAPABILITY AND STANDARD NOSE CONE CONFIGURATIONS

Nike-Cajun

Performance Capability
- Net Payload (lbs.) - 25 to 100
- Altitude (Nautical Miles) -75 to 115
- Launch Angle - 80°
- Acceleration (Max g) - 50 to 76

Payload Compartment

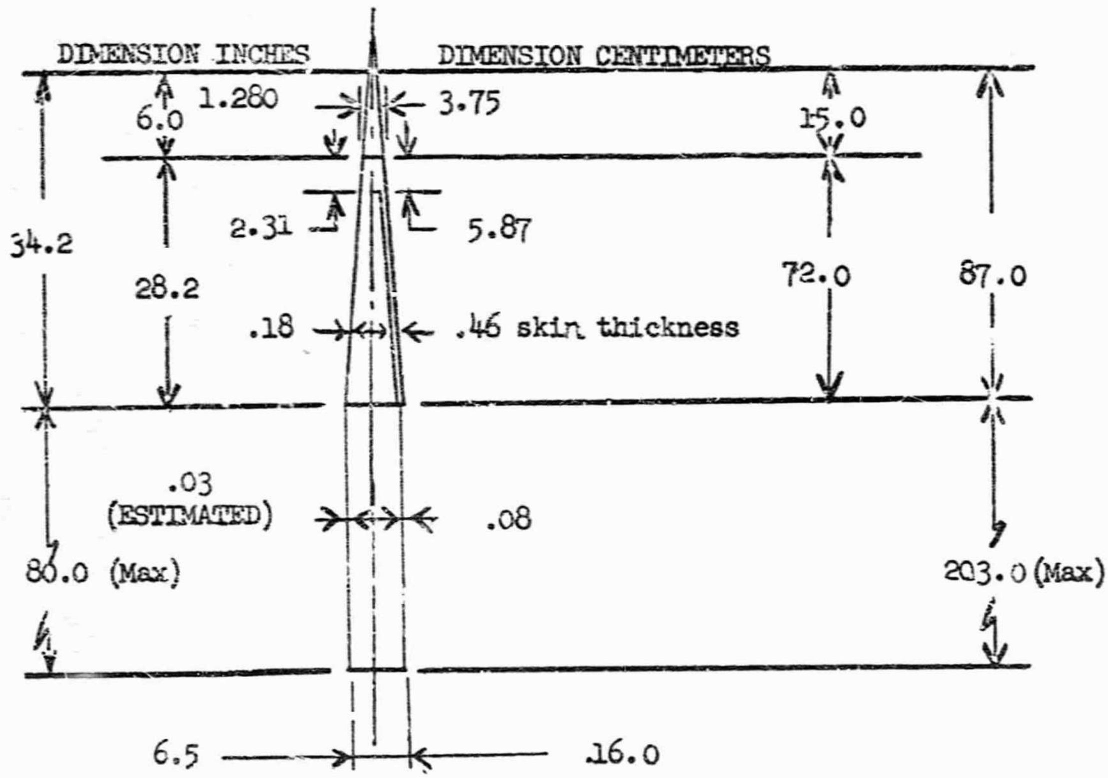



NOMINAL AVAILABLE PAYLOAD VOLUME = 2870 CU. IN. (.047 CU. METERS)

**Nike-Apache**

Performance Capability
- Net Payload (lbs.) - 50 to 80
- Altitude (Nautical Miles) - 100 to 132
- Launch Angle - 80°
- Axial Acceleration (Max g) - 34 to 40

Payload Compartment

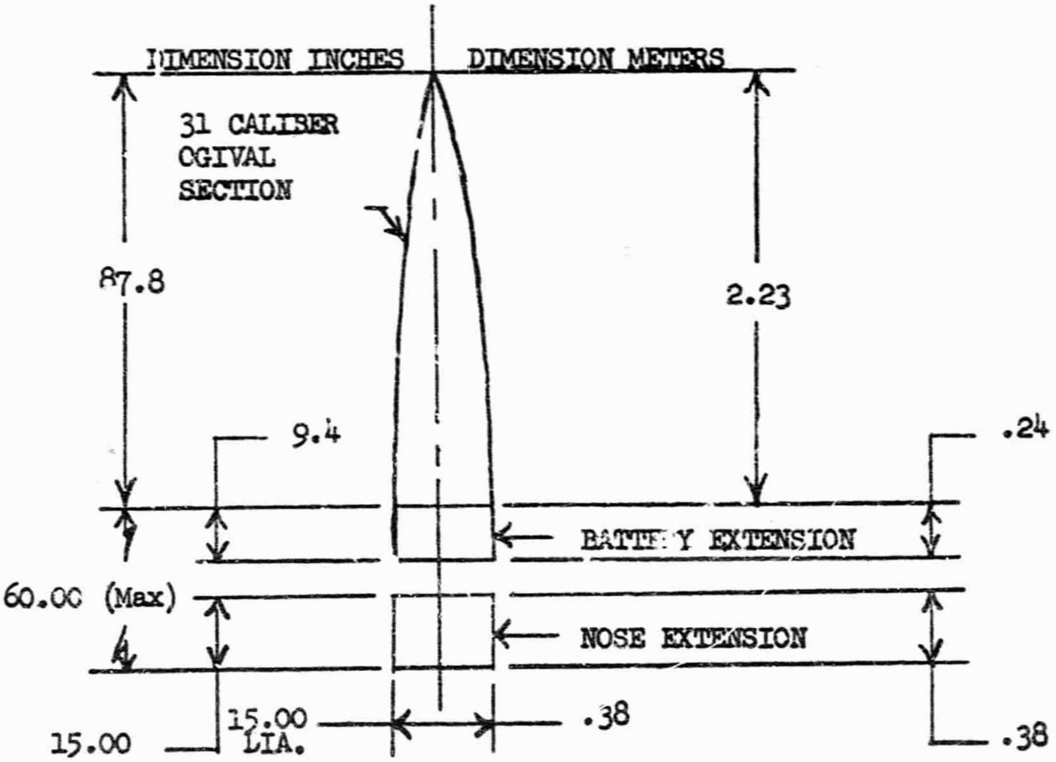



NOMINAL AVAILABLE PAYLOAD VOLUME = 2870 CU. IN. (.047 CU. METERS)

Aerobee 150 / 150A

Performance Capability
Net Payload (lbs.) - 100 to 300
Altitude (Nautical Miles) - 88 to 170
Launch Angle - 88°
Axial Acceleration (Max g) - 7.8 to 11.5

Payload Compartment

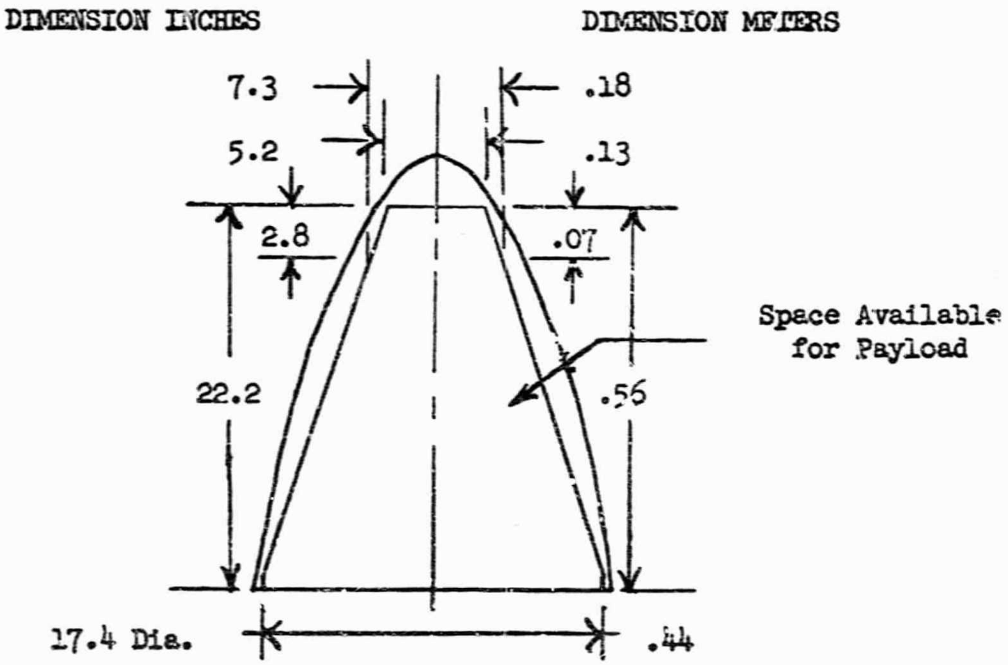



NOMINAL AVAILABLE PAYLOAD VOLUME
(INCLUDING EXTENSIONS) = 10.53 CU. FT. (.297 CU. METERS)

Argo D-4 (Javelin)

Performance Capability
- Net Payload (lbs.) - 50 to 175
- Altitude (Nautical Miles) - 380 to 700
- Launch Angle - 80°
- Axial Acceleration (Max) - 36 g

Payload Compartment

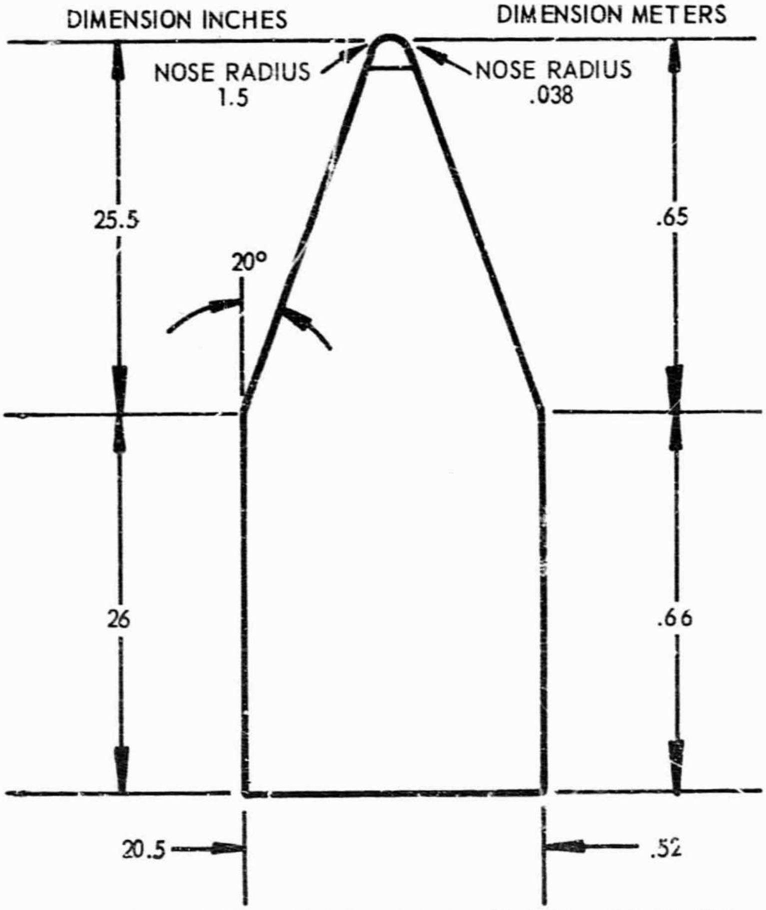



NOMINAL AVAILABLE PAYLOAD VOLUME = 1.4 CU. FT. (.040 CU. METERS)

Astrobee 1500

Performance Capability
- Net Payload (lbs) - 50 to 300
- Altitude (Nautical Miles) - 730 to 1750
- Launch Angle - 80°
- Axial Acceleration (Max) - 28 g

Payload Compartment




NOMINAL AVAILABLE PAYLOAD VOLUME 6.1 CU. FT.
(.226 CU. METERS)

Aerobee 350

Performance Capability

Net Payload (lbs) - 150 to 500

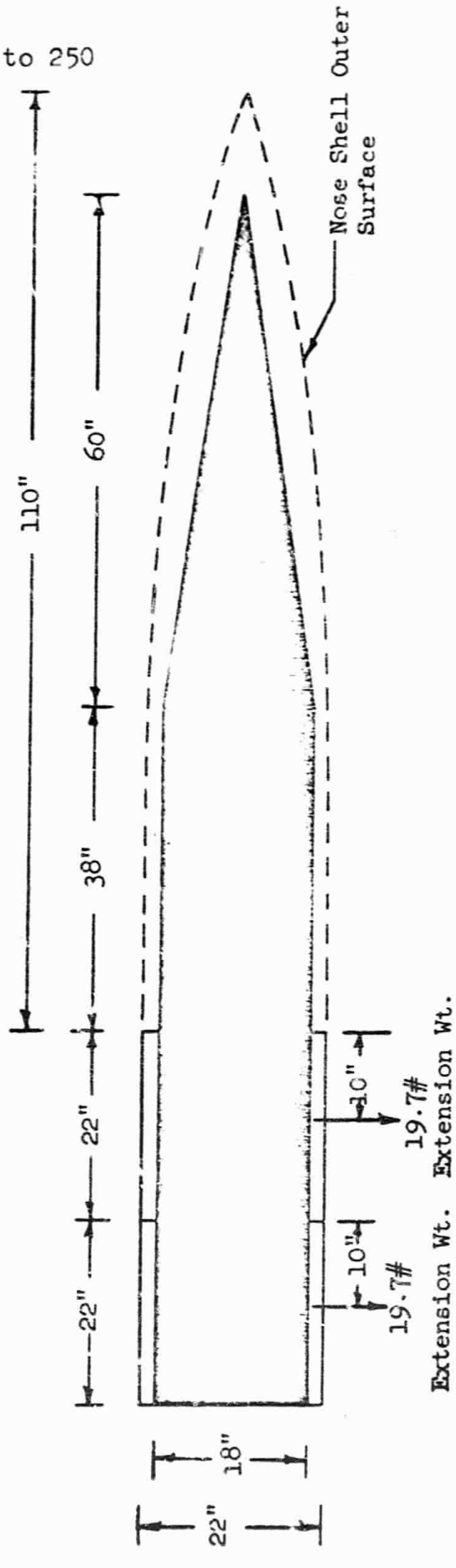
Altitude (Nautical Miles) - 175 to 250

Launch Angle - 88°

Axial Acceleration (Max) - 15 g

Payload Compartment

NOMINAL AVAILABLE PAYLOAD VOLUME
≈ 15.0 CU. FT. (.425 CU. METERS)



## SECTION II

## LAUNCH SITES AND CAPABILITIES

| U. S. - Operated Ranges | Capability |
|---|---|
| Eglin AFB, Florida (possible availability through USAF cooperation) | Nike-Cajun<br>Nike-Apache<br>Aerobee 150 |
| Ft. Churchill, Canada | Nike-Cajun<br>Nike-Apache<br>Aerobee 150<br>Javelin (ARGO D-4) |
| Pacific Missile Range, California | Nike-Cajun<br>Nike-Apache<br>Javelin (ARGO D-4)<br>Journeyman (ARGO D-8) |
| Wallops Island, Virginia | Nike-Cajun<br>Nike-Apache<br>Aerobee 150A<br>Javelin (ARGO D-4)<br>Journeyman (ARGO D-8) |
| White Sands, New Mexico | Aerobee 150 |

### Other Ranges

In addition, NASA may be able to arrange Nike-Cajun or Nike-Apache launchings for U. S. experimenters through international cooperative arrangements at locations of scientific interest in the Southern Hemisphere, at the geomagnetic equator, and at medium and high latitudes in the Northern Hemisphere.

SECTION III

## OTHER PERTINENT FACTS

Telemetry:

FM/FM telemetry system is most commonly used. Standard telemetry packages are available for all vehicles.

Recovery:

Standard land or water recovery systems are available for the Aerobee 150/150A vehicles.

A land recovery design is available for the Nike-Cajun or Nike-Apache vehicles.

Pointing Control:

A standard solar pointing control is available for the Aerobee 150/150A vehicles.

A standard inertial attitude control system is available for the Aerobee 150/150A vehicles. This is capable of selecting five targets during one rocket flight with an accuracy of approximately $\pm 2^{\circ}$ of arc.

# MANNED SPACE SCIENCE PROGRAM

The Manned Space Science Program is a scientific and applications effort to utilize and expand the capability of man in space in fulfillment of the objectives of the NASA. The scientific investigations presently being planned range from early "piggy-back" experiments to extended lunar exploration.

The general objectives of the Manned Space Science Program may be summarized as follows:

1. To extend the scientific knowledge of the solar system, interstellar and intergalactic space, and to apply space exploration and operations to peaceful uses for mankind.

2. To develop an efficient and sound scientific rationale for manned near-Earth, Lunar, and eventually planetary, exploration.

3. To establish scientific qualifications for scientist/astronauts and to train all flight crew members in the space sciences, so that they may fully utilize their sensory, manipulative, evaluative, and investigative capabilities in space.

4. To identify, develop, and apply scientific equipment and operational procedures for future manned space science investigations.

5. To develop and maintain a broad base for space-related science and technology through participation of other governmental agencies and the scientific community at large.

6. To plan for the acquisition of the space environment data needed for manned space systems engineering design and development, and to assure the analysis and compilation of these data into appropriate form for engineering use.

To fulfill these objectives, the Manned Space Science Program is currently planning scientific investigation opportunities in five mission categories:

I Apollo Earth-Orbital Missions

II Extended Apollo Manned Earth-Orbital Missions

III Apollo Manned Lunar Landing Missions

IV Extended Apollo Manned Lunar Orbital Missions

V Extended Apollo Manned Lunar Surface Missions

A summary description of each of these missions is provided below. Both the number of scientific experiments permitted and the extent to which the specification on spacecraft have been defined will be found to vary widely with the nature and date of the mission.

Specific recommendations concerning some of the missions and procedures for obtaining additional information on them are given under the appropriate mission descriptions. Scientists are urged to discuss their interests with the appropriate Manned Space Science Program officials, listed in the Introduction to this book, before developing and submitting formal proposals for experiments, instrument development, or supporting research.

Formal proposals for scientific experiments should be submitted in accordance with the instructions in the Introduction of this book and follow Form 1138, a, b, and c included in the rear of this book. Where additional information is required, it will be stated under the appropriate mission description. The forwarding letter should identify the proposal specifically with the appropriate mission.

## I. APOLLO EARTH-ORBITAL MISSIONS

### A. Introduction

The scientific objectives of these missions are:

1. To apply the unique capabilities of manned earth orbiting flights to the problems of atmospheric science and technology, earth sciences, earth resources, communications, and other peaceful applications with high scientific, economic, and social value.

2. To obtain quantitative data on scientist/instrument capabilities and to provide flight training of crews in order to fully exploit the integrated performance of the combination.

3. To develop and employ investigative techniques and equipment for scientific and applied purposes.

4. To employ both simple and complex, multi-purpose experiments to obtain scientific data in the biosciences, physical sciences, astronomy and astrophysics, working outside the Earth's atmosphere and in a near-zero gravity environment.

5. To conduct experiments and tests specifically designed to develop data, techniques and instrumentation for future manned and unmanned space missions.

The earliest Apollo Earth-Orbital launchings which can accommodate experiments are the fourth and fifth flights using Saturn IB launch vehicles. In these flights, a volume of two cubic feet and eighty pounds is being reserved in the Command Module Spacecraft, accessible to the crew for in-flight experiments. These flights will be launched from the Kennedy Space Center at 72 degree flight azimuths with mission durations of 10 to 14 days. The space vehicle, consisting of the Command Module, Service Module and the S-IVB stage will be separated and the Service Module propulsion system will be used to place the Command and Service Modules in a higher orbit (approximately 140 nautical mile circular). Upon completion of the orbital portion of the mission, the Service Module propulsion system will be used to de-orbit the space vehicle. The Command Module will re-enter, land, and be recovered.

B. Spacecraft

1. General Description

The Apollo spacecraft consists of the Command Module (CM), Service Module (SM), and the Lunar Excursion Module (LEM). In Figure 1, the spacecraft is shown in its lunar configuration. A brief description of each of the above modules is included in this section to provide a better understanding of the spacecraft, its functions, and its usefulness as a vehicle for spaceflight experiments.

Because no two Apollo spacecraft will be identical in configuration, it is extremely difficult to assign specific spaces that will be available for stowage of scientific equipment on every flight. Therefore, experiments will be placed in many locations throughout the spacecraft. When integrating experiments into the spacecraft, efforts will be made to secure the optimum location for success of the experiment subject to constraints of primary mission requirements, safety, weight control, difficulty of modifying the spacecraft, etc.

2. Command Module

a. General Description

The Command Module will house the crew during all phases of the mission except when the LEM is being used actively during the mission. The CM, shown in Figure 2, will contain crew support systems, displays, control equipment requiring direct access by the crew, and all systems needed for earth entry and landing.

The module is divided into three basic compartments: (1) the crew compartment, (2) the forward compartment, and (3) the aft compartment.

The crew compartment, which comprises the major portion of the CM, is approximately 365 cubic feet in volume. About 220 cubic feet of this space is available for the crew. This compartment is an oxygen pressurized (5 psia), three-man cabin that maintains a habitable environment for the crew during space flights. The crew compartment contains spacecraft controls and displays, observation windows, food, water, sanitation, and survival equipment. This area contains approximately three cubic feet for experiment equipment storage (figure 3).

The forward compartment is located at the apex of the conically shaped crew module. This compartment is unpressurized, and the center portion is occupied by the egress tube to permit the crew to debark from the spacecraft during flight. The major portion of the remaining area is occupied by the earth-landing system.

The aft compartment is an area located around the lower rim of the conical body. This area also is unpressurized and not accessible to the crew. It contains the reaction control motors, impact attenuation equipment, instrumentation, and consumable stowage.

Provisions are being made in the CM to incorporate a Scientific Experimentation Air Lock for the purpose of exposing certain experiments to the space environment outside the mold line of the CM and returning them to the oxygen pressurized crew compartment without venting the crew area.

The Scientific Experimentation Air Lock (see figure 4) will consist of three major assemblies: (1) the outer experiment door in the heat shield structure, (2) the air-lock chamber and outer gate, and (3) the experiment canister. The canister, with the experiment inside, will be removable from the chamber during the boost and re-entry phases to allow the center couch astronaut to view the main instrument panel.

The CM has five windows: a general observation window in the entrance hatch, two forward-looking rendezvous windows and two side-observation windows for horizon and earth-landing reference.

The Command Module is designed to provide a suitable crew environment for flights up to 14 days duration during both earth-orbital and lunar missions. The Command Module is the only recovered portion of the Apollo spacecraft on all manned space flights.

b. Experiment Locations in the Command Module

The CM compartment for experiment equipment stowage is shown in Figure 3. Space in the CM readily accessible to the crew is considered as premium space. Approximately 2.7 cubic feet of such premium space has

been reserved for stowage of scientific equipment. Only experiments requiring the attention of the crew should utilize this premium space. In planning such experiments, it should be recognized that all crew participation in monitoring scientific equipment will be time phased with other crew duties on a noninterference basis.

The following space in the CM may be considered for stowage of scientific equipment for specific missions on a negotiated basis:

1. The space reserved for lithium hydroxide cartridges which are not used for specific flights.

2. Space occupied by Portable Life Support System (PLSS) on missions not requiring one or more PLSS's.

3. Other locations, subject to negotiation.

In addition to the premium space and the special space available on certain flights, additional experimentation space can be negotiated with the incorporation of the Scientific Experimentation Air Lock, Figure 4.

The canister portion of the air lock will contain the experiment with dimensions of approximately 12 inches in length and a diameter of 6 inches. The canister design will be dictated by the specific scientific equipment utilizing the air lock.

The air lock mechanism will be incorporated into the side access hatch of the CM Block II spacecraft.

3. Service Module

a. General Description

The Service Module is an unmanned, unpressurized vehicle which contains stores and systems which do not require direct crew accessibility. This module contains the propulsion utilized for midcourse correction and for insertion into and from lunar orbit, fuel cells which provide spacecraft power, radiators for spacecraft cooling, and oxygen and hydrogen supplies. Any experimental equipment stored in this vehicle would be exposed to the surrounding space environment and would be available to the crew only by Extra Vehicular Activity (EVA). The SM remains attached to the CM throughout the mission, until it is separated from the CM just prior to earth re-entry. The SM is not recovered.

b. Experiment Locations in the Service Module

The Service Module is not accessible to the crew in flight; however, there is stowage space available around spherical and cylindrical tanks. Experiments which need exposure to the space environment but neither crew access nor recovery will generally be located in or on the SM.

Another concept for carrying experiments in the Service Module is the installation of a self-contained experiment equipment pallet in a segment of the SM as shown in Figure 5. The SM is divided into six pre-shaped segments (Sectors I through VI) and a central tunnel. Sector I is a 50-degree segment that has been allocated for experimental payloads. A pallet will be designed to fit into this sector for the purpose of accommodating a variety of experimental packages. The pallet will be equipped with five removable shelves spaced at 20-inch intervals, each capable of carrying 800 pounds of experimental equipment. To accommodate very large experiments, the bottom shelf is designed to support a single 4,000-pound experiment with the upper four shelves removed. In orbit, the outside cover for the pallet would be jettisoned to expose the experiments.

In addition to the above experimental payload space, the pallet will carry its own utilities section composed of cooling, power, communications, and data transmission subsystems. This compartment will be provided with a non-jettisonable cover so that the utilities subsystem equipment is not exposed to the space environment. A separate stabilization and control system (SCS) for the pallet is not provided since the Apollo SCS appears to be adequate for the vast majority of experiments that would be installed in the pallet area.

4. Lunar Excursion Module

a. General Description

The Lunar Excursion Module is designed to carry two men and required equipment from lunar orbit to the lunar surface, to provide support for the astronauts while on the lunar surface, and to return the men and lunar samples to the CM/SM in lunar orbit.

The LEM consists of two stages: (1) the descent stage which provides the braking-and-hover capability needed for lunar landing, and (2) the ascent stage for return to lunar orbit. The descent stage is unmanned and not accessible to the crew except during extra vehicular operation. This stage is useful for experimental purposes only to transport scientific equipment to the lunar surface.

The ascent stage houses the two crewmen during lunar operations. It provides a pressurized oxygen environment, food, water, communications equipment, and environmental control for the crew for a period up to 45 hours. The ascent stage has the necessary propulsion and guidance to return the crew from the lunar surface to lunar orbit and rendezvous with the Command and Service Modules. Thus, any equipment or data to be returned from the lunar surface must be stored in the ascent stage. Since this vehicle is not retained on the return journey to earth, all equipment within the ascent stage to be returned to earth must be transferred to the CM prior to leaving lunar orbit.

b. Experiment Locations in the Lunar Excursion Module

The Lunar Excursion Module, shown in Figure 6, will have a total of approximately 17 cubic feet of stowage space enroute to the moon. However, approximately 15 cubic feet of the above are in the descent stage to be abandoned on the moon (or in space on nonlunar flights). Approximately 2 cubic feet of space is available in the ascent stage of LEM for samples, film, data recording tapes, cameras, accessories, etc. The samples and equipment in the ascent stage will be transferred to the CM and eventually returned to earth.

The maximum payload for the ascent stage of LEM is 80 pounds. Since the weight of the two loaded lunar sample return containers will depend on unknown lunar soil density, the permissible weight of cameras, films, tapes, etc. cannot be determined. However, if the sample return containers reach maximum weight, the cameras will be left on the moon.

Within the 17 cubic feet of stowage space available in the descent and ascent stages of the LEM, every effort will be made to accommodate the maximum number of scientific experiments in addition to the primary lunar mission objectives. Experimenters will be encouraged and assisted by NASA in the packaging and miniaturization of such experimental equipment to maximize the benefits and results of the lunar surface experiments.

C. Stabilization

Although the flight attitude of the Command Module can be controlled, prime mission requirements or conflicting experiment requirements may restrict flight attitudes or the duration of attitude holds. Detailed flight control constraints will be determined when proposed experiments are evaluated for technical feasibility.

D. Spacecraft Capabilities & Environmental Considerations

A guide, known as the Apollo Experiments Guide, has been prepared which outlines the general procedures, constraints and schedules associated with the inclusion of scientific experiments in the program. Requests for the guide and any further information on these missions should be directed to the Director, Manned Space Science Program (Code SM), Attention: Dr. J. R. Gill, NASA Headquarters, Washington, D.C. 20546. Attention is invited to the "Schedule of Flights and Proposal Deadlines" at the front of this book.

E. Experiments

Experiments which already have been accepted for flight on these missions, include:

1. Frog Otolith Function

   Ames Research Center

2. Zero G-Single Human Cells

   University of Texas

3. Trapped Particles Asymmetry

   Jet Propulsion Laboratory

4. X-Ray Astronomy

   American Science and Engineering, Inc.

5. Micrometeorite Collection

   Dudley Observatory

6. UV Astronomical Camera Observations

   Northwestern University

II EXTENDED APOLLO MANNED EARTH-ORBITAL MISSIONS

A. Introduction

The manned lunar landing mission was established as a high priority national goal in 1961. Since that time, the requisite launch vehicles, spacecraft and ground facilities have been defined, hardware development and testing has begun, and detailed plans are being implemented to accomplish the lunar landing prior to 1970.

Planning studies by NASA and industrial contractors during the past two years have identified a number of manned space flights which could be accomplished using the Apollo lunar landing system for alternate missions of four to six weeks in earth orbit, up to 4 weeks in lunar orbit and up to 2 weeks on the lunar surface. These missions could accomplish scientific and technological objectives in many areas and capitalize on the system's capabilities, which represent a significant national asset.

The scientific objectives presently being planned for these missions are:

1. To determine man's capability to perform scientific and other useful tasks over extended periods in orbit.

2. To observe natural phenomena on (in) the terrestrial, lunar, and planetary surface (and atmospheres), and to determine possible useful economic applications from such observation.

3. To study physical, chemical, and biological processes in the zero-gravity environment.

4. To study the geophysical environment at earth-orbital altitudes.

5. To develop operational techniques and technology in preparation for manned exploration of the moon and other planets.

Experimental areas of interest and possible instrumentation are:

1. Space Science: biosciences; physical sciences; astronomy and astrophysics.

2. Earth-oriented Applications: atmospheric science and technology (aeronomy, meteorology, and air pollution); earth resources survey and inventory (agriculture, forestry, geology, hydrology, oceanography, geography, cartography); communications and control services (navigation and traffic control).

The experimental packages will vary greatly from flight to flight depending upon experimental requirements and spacecraft capabilities. Plans are being developed which correlate potential experimental requirements with the launch vehicle and operational capabilities.

B. Spacecraft

The basic Apollo space vehicle is designed for a nominal 14-day, 3-man space flight mission. By adding expendables and redundant or alternate components and subsystems, the spacecraft orbital lifetime can be increased to approximately 45 days. Longer duration flights are possible,

either by re-supply through rendezvous operations or by the use of advanced subsystems requiring new developments.

The Saturn IB launch vehicle can inject 36,500 pounds into a 105 n.mi. circular earth orbit in an eastward launch from Cape Kennedy. The Saturn V can place approximately 280,000 pounds into near-earth orbit and over 50,000 pounds into synchronous orbit.

The Apollo spacecraft, varying in weight from approximately 22,000 pounds to 106,000 pounds depending on mission requirements, will be capable of providing pressurized and unpressurized payload volume, electrical power, life support for a 2 or 3-man crew, data handling and orbital maneuver capability to support space flight experiments. Apollo spacecraft can be launched on Saturn IB or Saturn V vehicles.

The following Apollo spacecraft configurations can be considered for earth orbital missions:

1. For early missions, the lunar landing configuration, consisting of the Block II Command and Service Module (CSM) and the Lunar Excursion Module (LEM), for missions of 14 days duration.

2. For later missions, the extended Apollo configuration, consisting of modified spacecraft with added expendables and subsystems to permit operations for up to 45 days in earth orbit.

The Command Module (CM) will house a 3-man crew during launch, orbital flight and re-entry. It contains 366 cubic feet of pressurized volume for spacecraft and crew systems, experiment payloads and free volume (90 cubic feet). The basic Apollo CM is designed to return 80 pounds of lunar samples to earth. In extended Apollo missions, this might be increased to 250 pounds for 3-man missions and to 500 pounds for 2-man missions.

The Service Module (SM) contains the main spacecraft propulsion, attitude control and electrical power systems. One of the six sectors of the SM is designed to provide 210 cubic feet of unpressurized volume for experiment payloads. Unpressurized volume in other sectors could also be made available for experiments, if required. The SM main propulsion system will provide orbital maneuver and retro propulsion for the CM.

The basic Apollo LEM consists of two stages: an Ascent Stage to house a two-man crew and to provide propulsion for launch from the lunar surface to rendezvous in lunar orbit with the CSM; and a Descent Stage with adequate propulsion to permit a soft lunar landing from lunar orbit for the LEM and crew.

The LEM Ascent Stage contains 243 cubic feet of pressurized volume of which 122 cubic feet is available in the basic LEM design for experiments and crew work area. The LEM Descent Stage has provisions internally for 15 cubic feet of unpressurized volume for experiments. The LEM propulsion systems can be used in earth orbit to supplement the main SM engine for velocity changes to the combined CSM/LEM or for independent orbital maneuvers of the LEM. If the LEM descent propulsion system is not required for a particular mission, its removal makes available 1,500 cubic feet of unpressurized volume within the Descent Stage structure for mounting experiments.

The pressurized volume for experiments in the CM and LEM Ascent Stage is suitable for shirtsleeve operations by the crew. The unpressurized experiment areas in the SM and LEM Descent Stage are accessible to the crew during extra-vehicular operations. Both the CM and the LEM Ascent Stage have access hatches and multiple repressurization capabilities for use in extra-vehicular operations.

The Apollo spacecraft will provide a base level of volume, electrical power, environment control, stabilization, data management, communications and life support for nominal experiment requirements. Experiment demands beyond these base levels can be provided by mission unique equipment within payload weight and volume limits. In addition to supporting crews and experiments on single-launch missions, the Apollo space vehicle can be used to ferry men and supplies for rendezvous with previously launched spacecraft.

The basic LEM Ascent Stage may be used as a LEM Laboratory on extended Apollo missions. Removal of subsystems uniquely required for the lunar landing mission could provide 247 cubic feet of pressurized volume in the LEM Laboratory. Additional life support, electrical power and environment control systems could be installed internally or externally to support mission experiments.

For missions not requiring the LEM Descent Stage, a structural rack could be provided to support the LEM Laboratory within the Spacecraft LEM Adapter (SLA) during launch. Experiments or support equipment not requiring pressurized environment could be mounted on this rack within the volume (3,000 cubic feet) and weight limits for the mission.

For missions during which the CSM and LEM remain attached, the CM would be used as the basic crew living quarters and as a center for mission control and communications functions; the LEM Laboratory would be used primarily as an experiment module.

In missions which do not require the LEM, as much as 5,000 cubic feet of unpressurized volume could be available for large experiments within the Spacecraft LEM Adapter. This volume could accommodate such payloads as large telescopes or erectable antennas to be deployed and operated by the crew during extra-vehicular operations.

The Saturn Instrument Unit, mounted during launch between the S-IVB stage and the SLA, could be used to support orbital experiments with its electrical power, data management and communications systems in addition to those provided in the spacecraft.

The structural and dynamic interface between the spacecraft and launch vehicle for all extended Apollo missions will be within the specifications for the basic Apollo launches. No new facilities and no launch vehicle modifications will be required.

The table on the following page summarizes the earth orbital mission capabilities.

C. Spacecraft Capabilities and Environmental Consideration

A guide, known as the Extended Apollo Capabilities for Experiments, dated July 1965, has been prepared which outlines the space vehicles and earth based facilities to support the scientific experiments in the program. Requests for the guide and any further information on these missions should be directed to the Director, Manned Space Science Programs (Code SM), Attention: Dr. P. C. Badgley, NASA Headquarters, Washington, D.C. 20546. Attention is invited to the "Schedule of Flights and Proposal Deadlines" at the front of this book.

III. APOLLO MANNED LUNAR LANDING MISSIONS

A. Scientific Objectives

Overall:

1. Observations of natural phenomena including macro and micro-structure and composition

2. Collection of representative samples (for analysis on Earth)

3. Emplacement of monitoring equipment

Specific Objectives:

1. The study of the surface and near-surface features and chemical composition of the moon by geological and geochemical techniques

2. The study of the interior and core of the moon and its gravitational and magnetic fields by geophysical methods

3. The study of the lunar atmosphere or lack of it

4. The search for living matter or proto-organic matter on the moon.

LAUNCH VEHICLE
PERFORMANCE CAPABILITIES & FLIGHT PROFILES
FOR EARTH ORBITAL MISSIONS

| LAUNCH VEHICLES | Sa-IB | Sa-IB | Sa-V | Sa-V | Sa-V | Sa-V |
|---|---|---|---|---|---|---|
| **Mission Orbital Requirements** | | | | | | |
| Altitude | 200 | 200 | 200 | 19,350 | 200 | 200 |
| Inclination (Deg.) | 28.5 | 50 | 90 | 0 | -83.5 | 28.5 |
| **Launch Geometry** | | | | | | |
| Launch Azimuth (Deg.) | 90 | 44 | 108.5 | 90 | 108.5 | 90 |
| Powered Flight Operations | 2 Stages to Parking Orbit | 2 Stages to Parking Orbit | Yaw Steering During 2nd & 3rd Stages | 3 Stages to Parking Orbit | Yaw Steering During 2nd & 3rd Stages | 2 Stages to Final Orbit |
| **Parking Orbit** | | | | | | |
| Altitude | 80 | 80 | 100 | 100 | 100 | |
| Inclination (Deg.) | 28.5 | 50 | 90 | 28.5 | -83.5 | |
| **Transfer Orbit** | | | | | | |
| Injection by | SPS 1/ | SPS | S-IVB 2/ | S-IVB | S-IVB | NONE |
| Perigee Alt. (nm) | 80 | 80 | 100 | 100 | 100 | |
| Apogee Alt. (nm) | 200 | 200 | 200 | 19,350 | 200 | |
| **Mission Orbit** | | | | | | |
| Insertion by | SPS | SPS | S-IVB | S-IVB & SPS | S-IVB | S-II 3/ |
| Max. Wt. in Orbit (lbs) | 33,670 | 32,175 | 106,495 8/ | 57,250 | 106,495 | 220,000 |
| **Deorbit & Reentry** 7/ | | | | | | |
| Retro Propellant (lbs) | 1,085 | 1,085 | 1,085 | 15,800 | 1,085 | 1,085 |
| Returnable S/C Deboost Wt. (lbs.) | 21,200 | 21,200 | 21,200 | 21,200 | 21,200 | 21,200 |
| **Maximum Discretionary** 4/ Payload (lbs.) | 11,385 | 9,890 | 84,210 | 20,250 | 84,210 | 197,715 |
| **Est. Experiment** Wt. Available (lbs) 5/ | 2,000-3,000 | 1,000-2,000 | 50,000-70,000 | 12,000-15,000 | 50,000-70,000 | 50,000-70,000 6/ |

**Notes:**

1/ Service Module Propulsion System.
2/ Third stage of Saturn V.
3/ Second stage of Saturn V.
4/ Available for experiment systems, experiment support equipment, expendables for extending mission duration and propellant for orbital maneuvers.
5/ Choice within range shown depends on other mission requirements. See Note 4
6/ Additional experiment or maneuver propellants can be carried in the third (S-IVB) stage.
7/ Includes 10% $\Delta V$ margin plus 100 fps midcouse correction.
8/ This number is limited by structural considerations. The payload capacity exceeds this by approximately 30,000 lbs.

B. Experimental Areas and Instrumentation

Planned experimental areas:

1. Obtain "rock" samples

2. Visual/photographic reconnaissance from space vehicle (LEM)

3. Brief astronaut traverse with camera, TV, Jacob's staff, and hand geologic tools

4. Emplacement of small "geophysical" package(s) possibly containing:

   a. Passive seismometer (3-axis)

   b. Magnetometer (3-axis)

   c. Gravimeter

   d. Mass spectrometer

   e. Temperature probes

   f. Geophones and mortar (active seismology)

   g. Micrometeoroid detector

   h. Radiation and charged-particle detector

Four types of instrumentation will be employed:

| | Item | Estimated Weight |
|---|---|---|
| 1. | Containers for lunar samples (Return 80 pounds of samples) | 10-15 lbs. (Sample weight 80 lbs.) |
| 2. | Operational equipment in LEM | Not part of experiments allowance |
| 3. | Jacob's staff, camera, hand tools, etc. | 80 lbs. |
| 4. | Geological stay-behind package (50 watts of power) | 150 lbs. |

C. Spacecraft

The Apollo Command, Service and Lunar Excursion Modules described in Section I, above, are also applicable to these missions.

The Lunar Excursion Module (LEM), Figure 6, which will carry two Apollo astronauts to and from the moon's surface, will have approximately 17 cubic feet of storage space for 250 earth-pounds of scientific equipment for transfer to the moon's surface. Since changes in spacecraft capability can be expected in any systems development program, such as Apollo, a flexible payload is needed to assure the best utilization of the capability for each mission. NASA plans, therefore, to approve investigations for flight in a general sense and make assignments to specific flights as conditions permit.

The monitoring instruments are required to have a life of at least one year. They will share a common power supply (estimated at 50 watts) and telemetry system. Limited command capability will be maintained after the astronauts leave the lunar surface.

The estimated 17 cubic feet available for scientific equipment is divided between the descent stage (15 cubic feet) which is to be emplaced on the moon and only 2 cubic feet in the ascent stage for eventual return to earth. These 2 cubic feet are reserved for lunar samples. However, an additional 1 cubic foot (made up of various small spaces) may be available for other equipment return.

D. Contact

Scientists interested in submitting proposals for on-site lunar experiments and/or the study of returned lunar samples should write for further information to the Director, Manned Space Science Programs (Code SM), Attention: Mr. E. M. Davin, NASA Headquarters, Washington, D. C. 20546. Attention is called to the "Schedule of Flights and Proposal Deadlines" at the front of this book.

IV. EXTENDED APOLLO MANNED LUNAR-ORBITAL MISSIONS

A. Scientific Objectives

1. To provide geological and topographical mapping and survey data over the entire lunar surface in a systematic and synoptic manner using a sophisticated array of remote sensors operating in several parts of the frequency spectrum.

2. To provide data for selection of landing sites, areas of ground exploration, and lunar bases.

3. To provide detailed geological and geophysical support to the lunar surface explorations.

4. To provide operational support for lunar surface explorations: communications, navigation, and research/rescue assistance.

5. To lay groundwork for future manned planetary orbital flights.

B. Experimental Areas and Instrumentation

| | |
|---|---|
| Photographic Investigation | Topographical and geological mapping |
| IR Surveying | Thermal mapping, surface and subsurface |
| Passive Microwave Experiments | " " " " |
| Radio Frequency Reflectivity | Subsurface dielectric constant & conductivity |
| Radar, Altimetry and Surface State | Tectonic mapping |
| UV Absorption and Luminescence | Surface composition |
| X-Ray Fluorescence | " " |
| Gamma-Ray Mapping | " " |
| Remote Geochemical Sensing | " " |
| Micrometeorite Experiment | Particle flux at altitude |

The experimental package(s) are envisioned to consist of mapping and multispectral cameras; IR spectrometer; multi-channel microwave radiometer imaging system; VHF active use equipment; multi-frequency radar; passive or active UV sensing system; soft x-ray counter; gamma ray spectrometer; passive optical (geochemical) instrument; micrometeorite collection system with scope; and gravity gradiometer.

C. Spacecraft Capabilities

The instrumentation and spacecraft capabilities for these missions are generally similar to those described in Section II.

These mission trajectory profiles will be a lunar orbit with inclination from 0°, probably to 90°, at orbital altitudes of 20 to 150 nautical miles.

## D. Contact

Inquiries should be addressed to the Director, Manned Space Science Programs (Code SM), Attention: Dr. P. C. Badgley, NASA Headquarters, Washington, D.C. 20546. Attention is called to the "Schedule of Flights and Proposed Deadlines" at the front of this book.

# V. EXTENDED APOLLO MANNED LUNAR SURFACE MISSIONS

## A. Scientific Objectives

1. To observe natural phenomena, to collect representative samples, and to emplace geophysical instruments.

2. To obtain subsurface samples and to conduct subsurface experiments.

3. To conduct initial experiments using the moon as a space platform.

4. To conduct exploration traverses covering several hundreds of square kilometers.

## B. Experimental Areas and Instrumentation

1. Refined electrical, thermal, sonic, and radio-active measurements could be made in situ. Samples can be collected both on the surface and down to 30 meters by drilling. Preliminary sample analysis could be carried out.

2. Geophysical instrument packages can be deployed for long-terms study of the lunar environment.

3. Sites would be chosen to provide "ground-truth" support for the orbital surveys.

4. Small radio astronomy arrays may be emplaced and initial experiments conducted. A remote operation capability would be required.

5. A small optical telescope system (perhaps up to 40") could be deployed for initial experimentation. The telescope would be expected to operate remotely after astronaut departure.

6. Soil mechanics measurements would be made: e.g., penetrometer, shear, compression, and consolidation tests.

7. Environmental measurements would be continued: e.g., radiation, micrometeoroids and atmospheric investigations.

8. Geological and geophysical surveys could be conducted on short traverses (up to 16 km) using a small roving vehicle.

It is expected that some of the equipment would be employed for multiple purposes. The basic scientific instruments are estimated to weigh on the order of 1,000 pounds per flight with a power requirement of 500 to 1,000 watts. However, large pieces of equipment, like the drill, emplaced geophysical package, and the astronomical experiments could not be carried simultaneously and will require careful flight mission planning.

C. Spacecraft

Extended Apollo systems, using modifications of the LEM and CSM as described in Section II.

D. Payload

Total: To be determined

Scientific: 1,000 to 2,500 pounds estimated

E. Launch Phase

Launch Vehicle: Saturn V. Two launches per mission are planned

Mission Mode and Sites: Two basic types of lunar surface operations appear feasible. One would employ roving vehicle(s) with potential traverse radii of 3 to 10 miles. The other type would be a stationary shelter for various scientific investigations lasting up to 14 days. The sites for these activities have not been selected, but possibilities include a rille complex (Hyginus), the interior of a crater (e.g., Alphonsus, Archimedes), highlands, the walled plain of Pluto, and the far side.

F. Duration

Up to 14 days

G. Number of Flights and Time Period

4 to 6 lunar surface missions in the 1970 to 1973 time period

H. Communications/Data Handling/Tracking

The Manned Space Flight Net would be employed. While the two astronauts are on the surface, much of the scientific data might be recorded for later compressed transmission. Approximately 250 pounds of samples could be returned with the crew. Selected film footage (e.g., optical astronomical photographs) would also be returned. Landing(s) on the far side may entail transmissions relayed by a lunar orbiter or the CSM.

The geological/geophysical and astronomical "stay-behind" experiments would place additional requirements for periodic data and command transmissions. Details have not yet been investigated.

Close collaboration is envisioned with earth-based scientists. It is expected that the scientist/astronauts will require consultation for possible changes in exploration or measurement plans during the course of the missions.

I. Contact

The Manned Space Science Program is conducting and sponsoring the study and research necessary to determine the scientific investigations to be conducted on the moon following the early Apollo missions. This work covers requirements for exploration of the moon itself and, in addition, experiments and investigations using the moon as a base for further exploration of the universe. Scientists are urged to discuss their interests with Manned Space Science program officials before developing and submitting formal proposals for experiments, instrument development, or supporting research. Inquiries should be addressed to the Director, Manned Space Science Programs (Code SM), Attention: Dr. R. J. Allenby, NASA Headquarters, Washington, D.C. 20546. Attention is called to the "Schedule of Flights and Proposed Deadlines" at the front of this book.

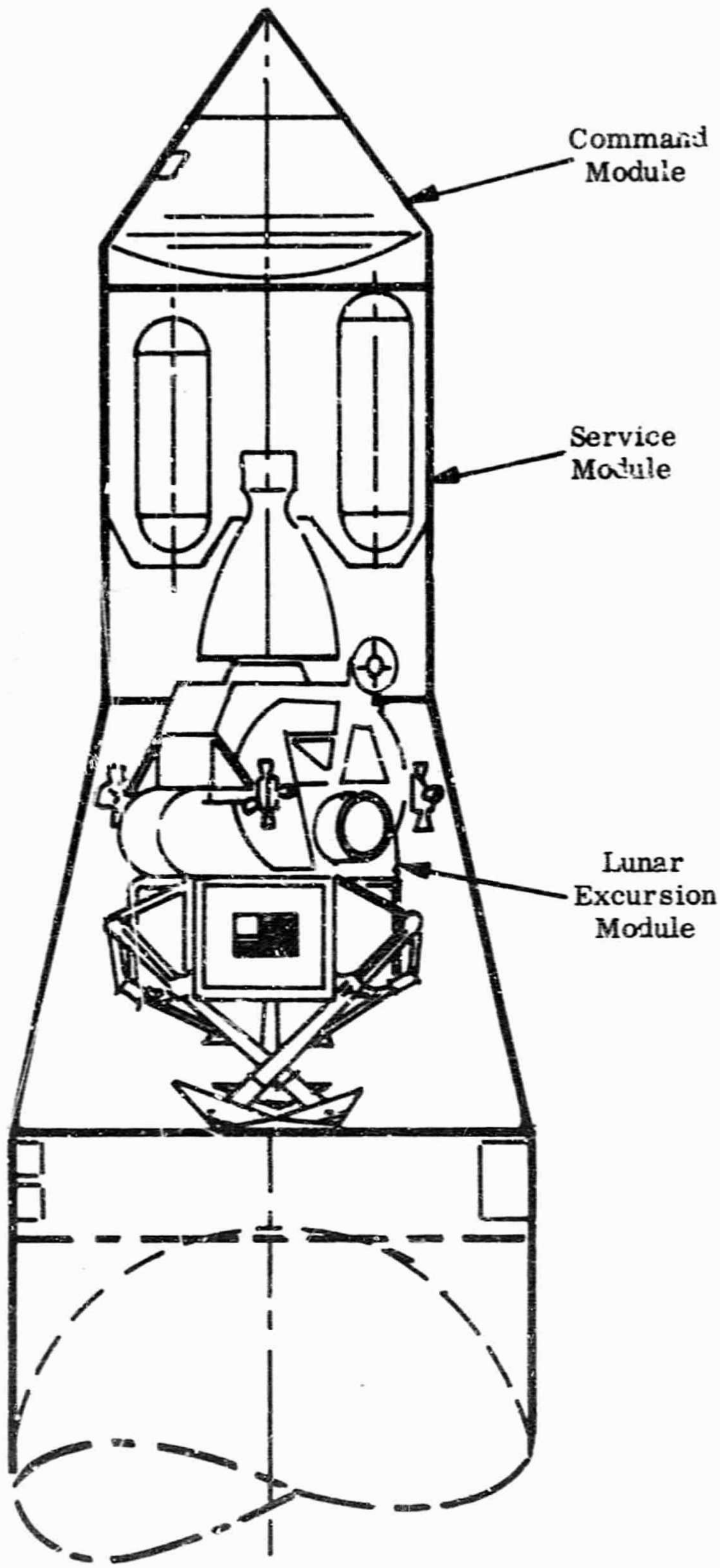



Figure 1. Saturn V Spacecraft, Lunar Mission Configuration

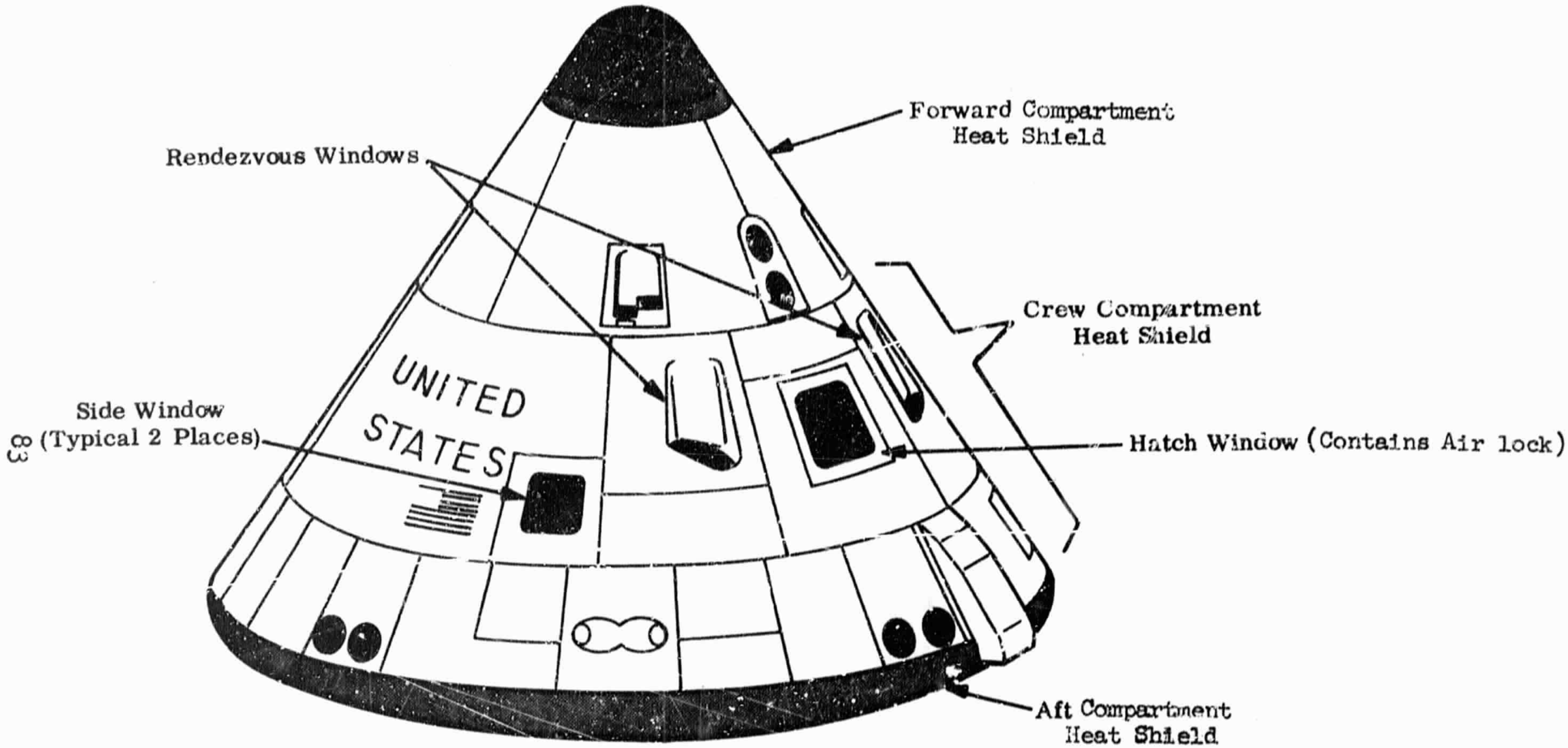



Figure 2. Command Module, Block II

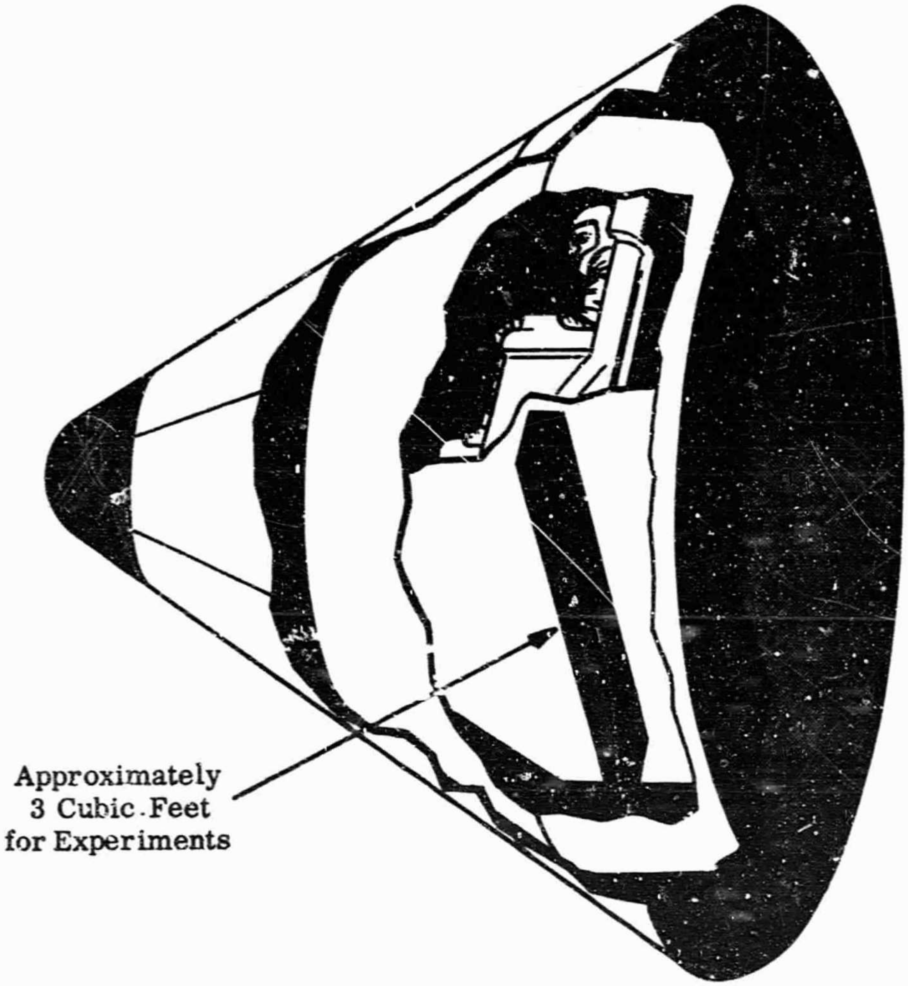



Figure 3. Command Module, Block II, Experiment Equipment Stowage

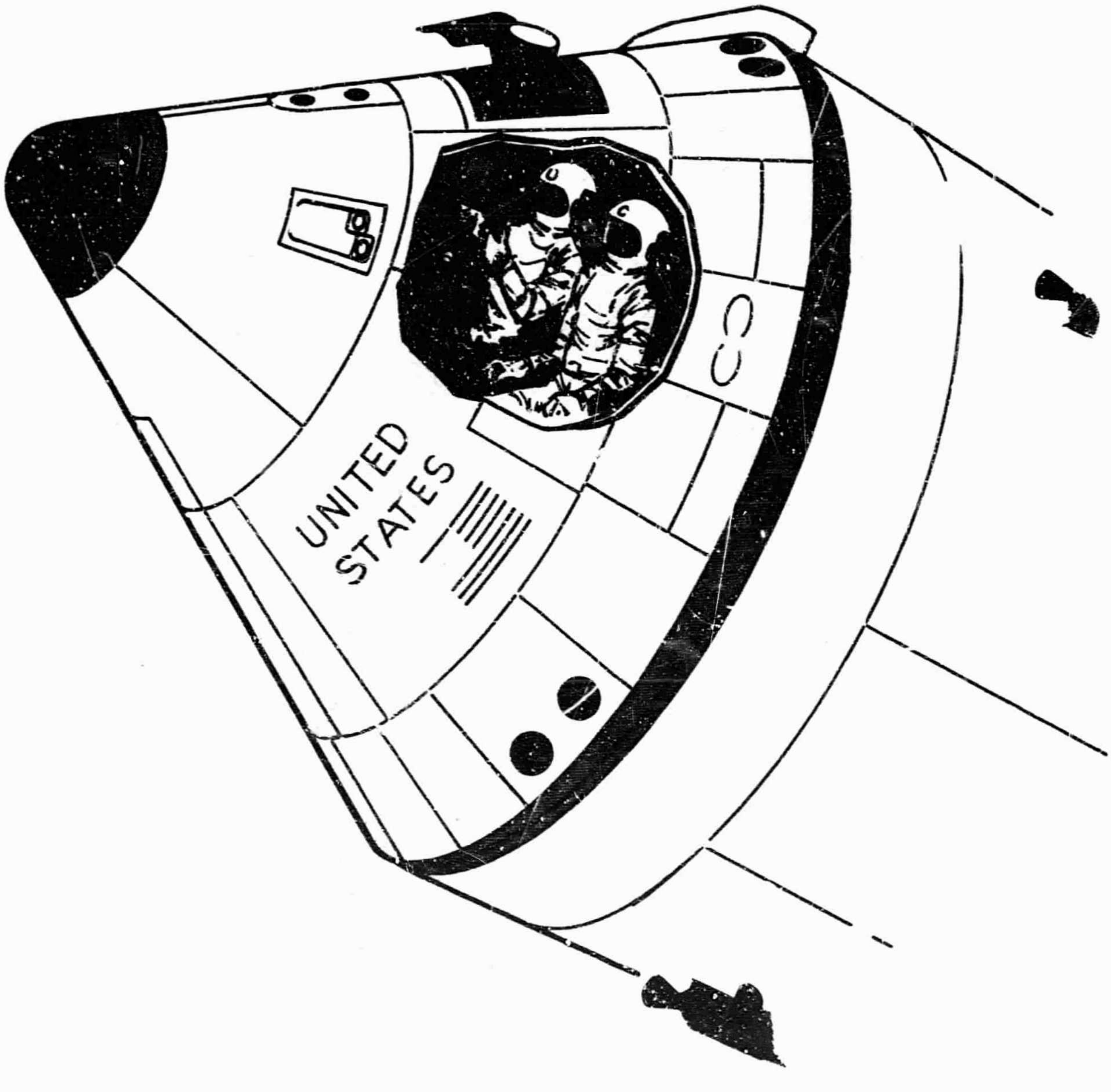



Figure 4. Command Module, Block II, Air Lock Experiment Configuration

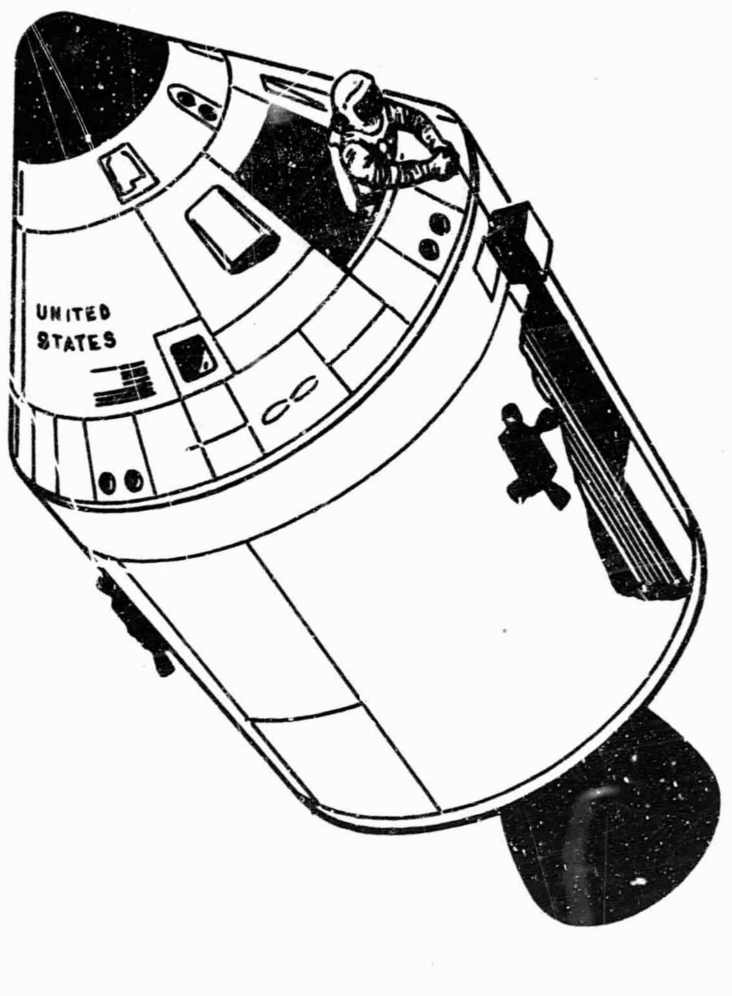



Figure 5. Command/Service Module, Experiment Pallet and Location

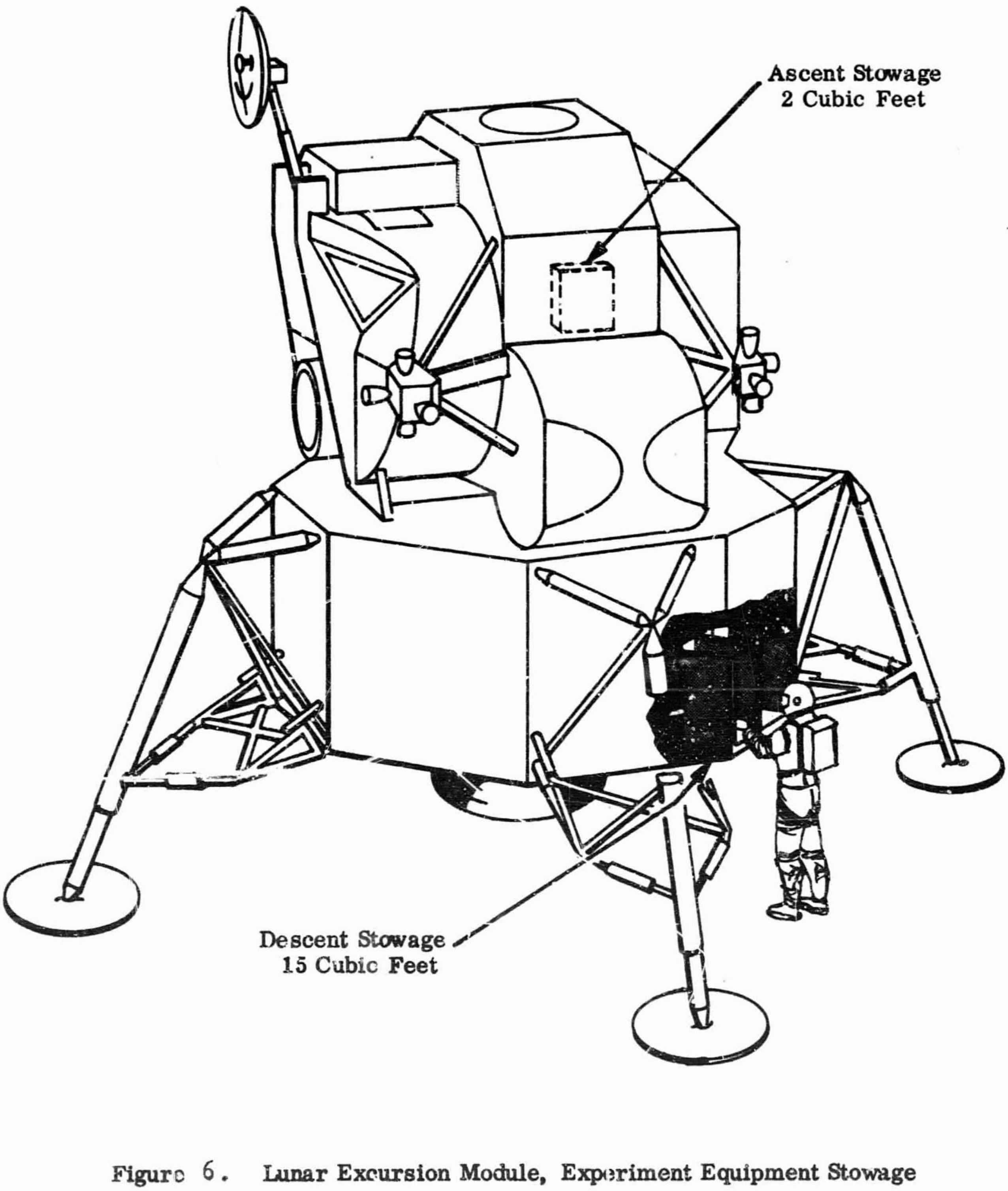



Figure 6. Lunar Excursion Module, Experiment Equipment Stowage

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## APOLLO EARTH ORBITAL SCIENTIFIC EXPERIMENT PROPOSAL

| APOLLO EARTH ORBITAL SCIENTIFIC EXPERIMENT PROPOSAL |
|---|
| TITLE OF EXPERIMENT |
| NAME OF INVESTIGATOR |
| NAME OF SPONSORING INSTITUTION |

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PAGE 1 OF 2

| 1. TITLE OF EXPERIMENT | DATE OF SUBMISSION |
| --- | --- |
| | *(For Headquarters use only.)* DATE RECEIVED BY SM |

**2. SPONSOR**

| NAME OF SPONSORING INSTITUTION | |
| --- | --- |
| ADDRESS | TELEPHONE |
| NAME OF PRINCIPAL ADMINISTRATOR RESPONSIBLE FOR EXPERIMENT | |

**3. INVESTIGATORS**

| NAME OF PRINCIPAL INVESTIGATOR | |
| --- | --- |
| ADDRESS | TELEPHONE |

| NAMES OF OTHER INVESTIGATORS | ADDRESS | TELEPHONE |
| --- | --- | --- |
| | | |

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## SCIENTIFIC INFORMATION AND PROGRAM PLAN - PART I

1. PURPOSE AND OBJECTIVE OF THE EXPERIMENT

(Attach additional sheets if necessary, identifying items by number.)

2. STATE OF PRESENT DEVELOPMENT IN THE FIELD:

(Attach additional sheets if necessary, identifying items by number.)

3. SPECIFY PARAMETERS TO BE MEASURED INCLUDING NUMERICAL VALUES EXPECTED AND OUTLINE THE RESEARCH PROGRAM.

(Attach additional sheets if necessary, identifying items by number.)

4. PRESENT AN ANALYSIS OF THE PERFORMANCE OF THE PROPOSED EXPERIMENT *(e.g., dynamic range, signal to noise ratio, etc.)*

*(Attach additional sheets if necessary, identifying items by number.)*

5. DISCUSS THE METHOD OR POSSIBLE METHODS FOR THE ANALYSIS AND INTERPRETATION OF THE DATA *(e.g., the statistical validity)*

*(Attach additional sheets if necessary, identifying items by number.)*

6. DESCRIBE THE EXPERIMENTAL PROCEDURE TAKING INTO CONSIDERATION THE ENVIRONMENT AND ORBITAL CHARACTERISTICS OF THE SPACECRAFT. INCLUDE ANY CONSTRAINTS ON SPACECRAFT ATTITUDE, POINTING ACCURACY, AND STABILITY. EXPLAIN WHY THE ASTRONAUT IS NECESSARY TO THE PERFORMANCE OF THIS EXPERIMENT. DESCRIBE IN DETAIL OPERATIONS PERFORMED BY THE ASTRONAUT AND TIME CONSUMED DURING EACH OPERATION. *(Include length of time the spacecraft must hold a given attitude.)*

*(Attach additional sheets if necessary, identifying items by number.)*

| 7. ASTRONAUT TIME REQUIREMENT SYNOPSIS | | |
|---|---|---|
| PREFLIGHT TIME | IN-FLIGHT TIME | POSTFLIGHT TIME |
| | | |

8. DESCRIBE THE PREFLIGHT AND POSTFLIGHT REQUIREMENTS ON THE ASTRONAUT

(Attach additional sheets if necessary, identifying items by numbers.)

9. DISCUSS PREFLIGHT AND RECOVERY FACILITIES REQUIRED AND DATA HANDLING PROCEDURES

(Attach additional sheets if necessary, identifying items by number.)

## ENGINEERING INFORMATION AND PROGRAM PLAN - PART II

1. DESCRIPTION OF EQUIPMENT *(Sketch major assemblies in Item 5.)*

*(Attach additional sheets if necessary, identifying items by number.)*

2. DESCRIBE SPACECRAFT MODIFICATIONS REQUIRED FOR ACCOMODATION OF EQUIPMENT. INDICATE PREFERRED MOUNTING CONFIGURATION HERE OR IN ITEM 5

*(Attach additional sheets if necessary, identifying items by number.)*

| 3. WEIGHT | | 4. VOLUME | |
|---|---|---|---|
| TOTAL WEIGHT: | | TOTAL VOLUME: | |
| WEIGHT OF SEPARATE ASSEMBLIES *(If any)* | | VOLUME OF SEPARATE ASSEMBLIES *(If any)* | |
| ASSEMBLY #1 | | ASSEMBLY #1 | |
| ASSEMBLY #2 | | ASSEMBLY #2 | |
| ASSEMBLY #3 | | ASSEMBLY #3 | |

5. ENVELOPE *(Sketch each assembly (Designate 1, 2 or 3) indicate nominal and limiting values of each major dimension.)*

*(Attach additional sheets if necessary, identifying items by number.)*

| 6. | POWER | | |
|---|---|---|---|
| **TOTAL POWER:** | STANDBY | AVERAGE | MAXIMUM |

| POWER CONSUMED BY SEPARATE ASSEMBLIES | | | |
|---|---|---|---|
| ASSEMBLY #1 | STANDBY | AVERAGE | MAXIMUM |
| ASSEMBLY #2 | STANDBY | AVERAGE | MAXIMUM |
| ASSEMBLY #3 | STANDBY | AVERAGE | MAXIMUM |

IF POWER CONSUMPTION IS NOT CONSTANT, INDICATE POWER PROFILES BELOW:

*(Attach additional sheets if necessary, identifying items by number.)*

| 7. | THERMAL CONSTRAINTS | |
|---|---|---|
| | OPERATING TEMPERATURE LIMITS OF EACH ASSEMBLY | |
| ASSEMBLY #1 | MINIMUM $^{\circ}C$ | MAXIMUM $^{\circ}C$ |
| ASSEMBLY #2 | MINIMUM $^{\circ}C$ | MAXIMUM $^{\circ}C$ |
| ASSEMBLY #3 | MINIMUM $^{\circ}C$ | MAXIMUM $^{\circ}C$ |
| | STORAGE TEMPERATURE LIMITS OF EACH ASSEMBLY | |
| ASSEMBLY #1 | MINIMUM $^{\circ}C$ | MAXIMUM $^{\circ}C$ |
| ASSEMBLY #2 | MINIMUM $^{\circ}C$ | MAXIMUM $^{\circ}C$ |
| ASSEMBLY #3 | MINIMUM $^{\circ}C$ | MAXIMUM $^{\circ}C$ |

OTHER THERMAL CONSTRAINTS

8. OTHER ENVIRONMENTAL CONSTRAINTS *(List any remaining constraints such as preferred or prohibited orientation of assemblies with respect to direction of maximum vibration and acceleration, susceptibility to RFI, etc.)*

*(Attach additional sheets if necessary, identifying items by number.)*

9. TELEMETRY

| | OUTPUT 1 | OUTPUT 2 | OUTPUT 3 | OUTPUT 4 |
|---|---|---|---|---|
| FUNCTION | | | | |
| MUST MEASUREMENT BE CONTINUOUS | | | | |
| MINIMUM NUMBER OF SAMPLES PER SECOND | | | | |
| ACCURACY OF MEASUREMENT | | | | |
| MAXIMUM BIT RATE *(Digital only)* | | | | |
| MINIMUM FREQUENCY RESPONSE *(Analog only)* | | | | |

ADDITIONAL INFORMATION

*(Attach additional sheets if necessary, identifying items by number.)*

10. **DEVELOPMENTAL PROGRAM**

| ITEM | WHERE PERFORMED | BEGINNING DATE | COMPLETION DATE |
|---|---|---|---|
| PRELIMINARY ELECTRICAL DESIGN | | | |
| PRELIMINARY MECHANICAL DESIGN | | | |
| PRELIMINARY MOCK UP FABRICATION | | | |
| FINAL ELECTRICAL DESIGN | | | |
| FINAL MECHANICAL DESIGN | | | |
| EXACT MECHANICAL MOCK UP CONSTRUCTION | | | |
| PROTOTYPE FABRICATION | | | |
| PROTOTYPE ENVIRONMENTAL TEST | | | |
| FLIGHT UNIT FABRICATION | | | |
| FLIGHT UNIT ENVIRONMENTAL TEST | | | |
| FLIGHT SPARE FABRICATION | | | |
| FLIGHT SPARE ENVIRONMENTAL TEST | | | |

| MANAGEMENT PLAN - PART III | *(For Headquarters use only.)* DATE RECEIVED BY SM |
|---|---|

TITLE OF EXPERIMENT

| SPONSORING INSTITUTION | ADDRESS |
|---|---|

1. **RESPONSIBILITIES**

| INDIVIDUAL | NAME | ADDRESS |
|---|---|---|
| A. RESPONSIBLE ADMINISTRATOR | | |
| B. PRINCIPAL INVESTIGATOR | | |
| C. CO-INVESTIGATOR(S) | | |

D. PRINCIPAL INVESTIGATOR'S ROLE IN RELATION TO THIS EXPERIMENT

E. RESPONSIBILITIES OF OTHER KEY PERSONS

*(Attach additional sheets if necessary, identifying items by number.)*

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## COST BREAKDOWN

*Attach a sheet (or sheets) giving the costs of the experiment for which NASA support will be required, in the following format, and in the detail specified. Separate cost breakdowns should be submitted for the three phases of experiment funding shown in Item 3, "Quarterly Funding Requirements".*

| ITEM | AMOUNT |
|---|---|
| DIRECT LABOR *(Separate by Labor Category; Rate per hour or man-month; Personnel involved, what they will do, etc.)* | $ |
| MANUFACTURING BURDEN *(Overhead)* RATE ( %) *(Flight experiments normally will be supported by contracts rather than grants.)* | |
| MATERIALS *(Total) (Bill of Material, including estimated cost of each major item.)* | |
| SUBCONTRACTS *(List those over $25,000) (Specify the vendor if possible, and the basis for the estimated cost.)* | |
| SPECIAL EQUIPMENT *(Total) (List of lab equipment, proposed uses, and estimated cost.)* | |
| TRAVEL *(Estimated number of individual trips, destinations, and costs.)* | |
| ANY OTHER ITEMS *(Total) (Explain in detail similar to the above.)* | |
| **TOTAL COSTS** | $ |
| GENERAL AND ADMINISTRATIVE RATE ( ) | $ |
| **TOTAL ESTIMATED COST** | $ |

*Experimenters who request to conduct the proposed experiment as an extension of an existing grant or contract, should list the grant or contract number and the name and address of the NASA technical monitor below.*

| GRANT OR CONTRACT NO. | NAME AND ADDRESS OF NASA TECHNICAL MONITOR |
|---|---|
| | |

3. **QUARTERLY FUNDING REQUIREMENTS** *(Dollars in thousands)*

LAST FLIGHT UNIT DELIVERED — LAUNCH — RELEASE OF DATA

| | | | | | | | | | | | | | | | | | | | | TOTALS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DESIGN, DEVELOPMENT, FABRICATION, TEST *(Mock-ups and prototypes)* AND GENERAL SUPPORT OF EXPERIMENT | | | | | | | | | | | | | | | | | | | | $ |
| FABRICATION, TEST AND DELIVERY *(Flight units and spares)* | | | | | | | | | | | | | | | | | | | | $ |
| DATA ANALYSIS AND PUBLICATION | | | | | | | | | | | | | | | | | | | | $ |
| GRAND TOTAL | | | | | | | | | | | | | | | | | | | | $ |





* U.S. GOVERNMENT PRINTING OFFICE : 1965 O—782-864